BBC SCIENCE • TECHNOLOGY • FUTURE

FOCUS

Issue 243 July 2012 £3.95

What makes people left-handed? *Q&A, p76*

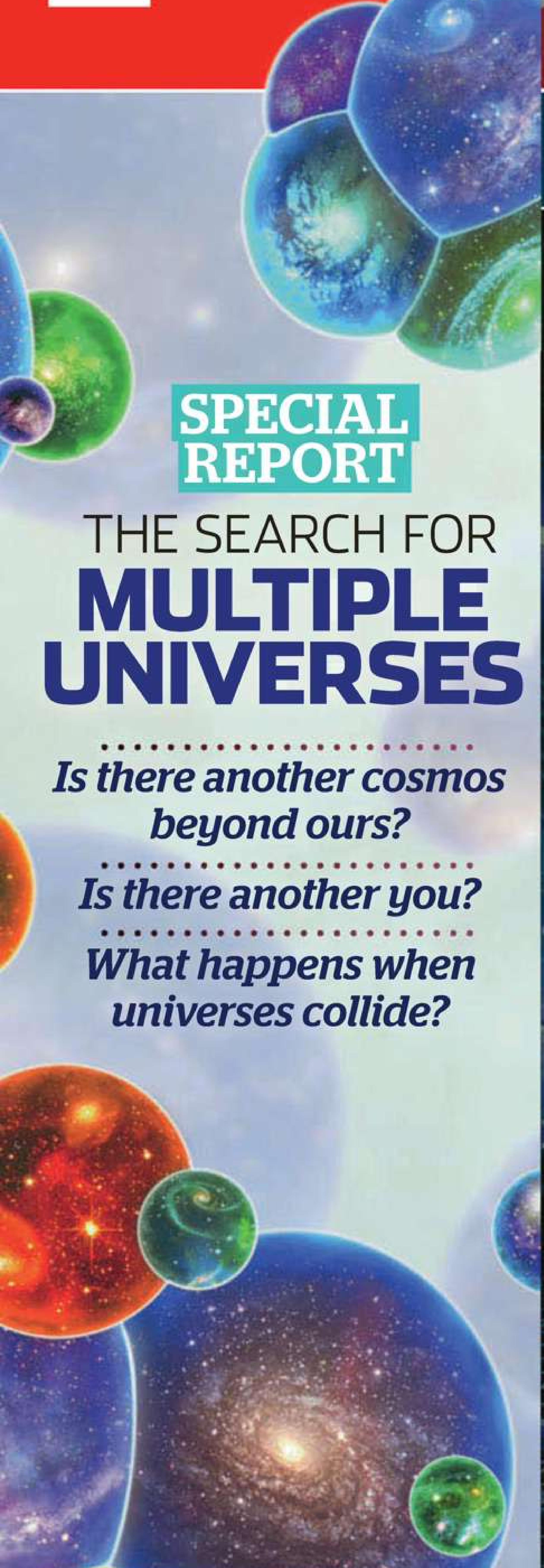
BBC one **DR MICHAEL MOSLEY:** "I WAS A LIVING EXHIBIT"

How to build a BRAIN

The £1 billion computer project that's aiming to reconstruct the way we think

PLUS

Inside the mind of Alan Turing



SPECIAL REPORT

THE SEARCH FOR **MULTIPLE UNIVERSES**

Is there another cosmos beyond ours?

Is there another you?

What happens when universes collide?

Mining space
Can we really extract metal from asteroids?

Glowing cats!
The molecule that changed medicine

How birds fly
Cracking nature's greatest secret

NEW CITROËN C-ZERO. 100% ELECTRIC. FROM ONLY £249 PER MONTH*

Thousands of scientists and engineers have utilised the most advanced technology available to ensure we are never without power. It's up to us to use this power wisely and thanks to the new Citroën C-Zero that's the easy bit. With 93 miles on a single charge, zero noise, generous cabin space, regenerative braking, and an 80% range on a thirty minute quick charge the new Citroën C-Zero means you can harness the real power of electricity.

Scan the code to watch our TV commercial, call Citroën Fleet Connect on 08457 940940 for further information or to arrange a test drive.

CRÉATIVE TECHNOLOGIE

CITROËN

*Offers apply to qualifying new Citroën vehicles ordered from 01/05/12 – 30/06/12 for business users only and excludes VAT. Rental prices shown are the monthly rentals on a 4 year agreement of 10,000 miles per annum with 1 monthly rental in advance followed by 47 monthly rentals. Rental includes: delivery to dealership, Citroën Roadside Assistance and Government First Registration Fee. Full maintenance package available at an additional cost. Finance subject to status. Written quotations available on request from Citroën Financial Services, Quadrant House, Princess Way, Redhill, Surrey RH1 1QA. Over 18s only. A guarantee may be required. Offers, prices and specification correct at time of going to press from participating Dealers. Terms and conditions apply. Please ask us for details. Subject to stock availability. Finance offers apply to UK only.

Welcome

July 2012

SUBSCRIBE AND
TRY 5 ISSUES FOR £5 p30
Already a subscriber? Turn to page 30 for an exclusive feature on the frontiers of mathematics

One hundred years ago, the pioneering computer scientist, Alan Turing, was born. One of the greatest thinkers of his time, he was instrumental in winning World War II for the Allied powers by helping to crack the Germans' Enigma code. Among his other incredible insights, which we take a look at on p40, he believed the brain worked just like a computer, and could therefore be replicated.

Incredibly, his vision for an artificial brain is no longer mere speculation. Scientists believe they might be able to understand the brain by building one of their own in a supercomputer.

It's no mean feat. Your brain contains 86 billion nerve cells, called neurones. It's a staggering number – for comparison, there are 'only' around 300 billion stars in our Galaxy. But while it's a lot, the number of brain cells alone may not be all that important in the grand scheme of things. Rather, it's the connections between them that make us intelligent. Your brain forms a million new connections each second, and the pattern of those connections is constantly changing.

If the team of researchers is successful, we would have a better understanding of decision-making and memory. In other words, the things that make us tick. It could also shed light on diseases like Alzheimer's. Turn to p32 for more on the quest to build a brain.

I'd be fascinated to know what a man like Turing would have made of the search for multiple universes. It sounds esoteric, to be sure. Yet in the next few months, hard evidence might emerge that our Universe isn't the only one. The possibilities might literally be endless – a staggering discovery that, in my view, ranks alongside the idea of the Big Bang itself. Robert Matthews delves deeper on p54.

And last but not least, the UK's biggest science festival, in Cheltenham, runs from 12 to 17 June. We'll be there and we hope to meet many of you at the show. In the meantime, we provide our pick of the top events on p81.

Until next issue,

Graham

The *Big Book Of Answers* app collects the very best questions from the *Focus* Q&A section and adds a sprinkling of incredible Megapixel images. To download it, visit the App Store and enter 'Big Book of Answers' in the search box.

Available on the App Store

What I've found out this month

- Simulating the brain would involve crunching an amount of data equivalent to all the stored information in the world (p34)
- I'd have to travel a long way to meet another version of myself! (10 to the power of 10 to the power of 29 kilometres) (p58)
- A hummingbird is able to beat its wings 80 times a second (p62)

Experts

Moheb Costandi
Mo gained an MSc in neuroscience before becoming a writer and is the brains behind the popular Neurophilosophy blog. On p32 he looks at the efforts to build an artificial human brain.

Sarah Castor-Perry
Sarah studied zoology and presents *The Naked Scientists* podcast. On p60, she looks at the work being carried out at the University of Montana's 'Flight Lab', examining how birds fly.

Zoe Cormier
A Canadian science writer, Zoe co-founded Guerilla Science, an organisation that brings science to arts festivals. She studied zoology and writes about the glowing molecule GFP on p46.

Edward Castronova
Professor Edward Castronova is an expert on the science of video games at Indiana University, specialising in the sociology of virtual worlds. On p64, he explains how games influence our lives.

How to get in touch

☎ Phone

Subscription enquiries (and back issues)
0844 844 0260*
Editorial enquiries
0117 314 7388
Advertising enquiries
0117 314 8750

@ Email

Subscription enquiries
focus@servicehelpline.co.uk
Editorial enquiries
post@sciencefocus.com
Advertising enquiries
steve.grigg@immediate.co.uk

✉ Post

Subscription enquiries
Focus, FREEPOST LON 16059, Sittingbourne ME9 8DF
Editorial and advertising enquiries
Focus, Immediate Media Company Bristol Ltd,
Tower House, Fairfax Street, Bristol, BS1 3BN

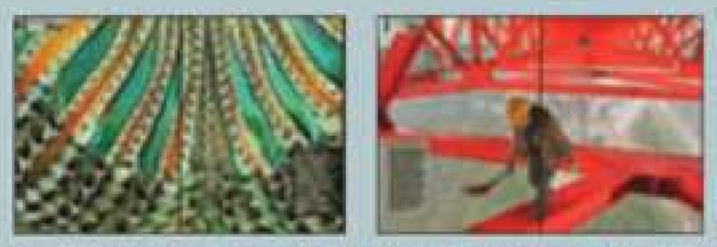
*Calls to this number from a BT landline will cost no more than 5p per minute. Calls from mobiles and other providers may vary. Lines are open 8am-8pm weekdays & 9am-1pm Saturday.

COVER: ILLUSTRATION BY OLIVER BURSTON, MAGIC TORCH

July 2012

Contents

Issue guide

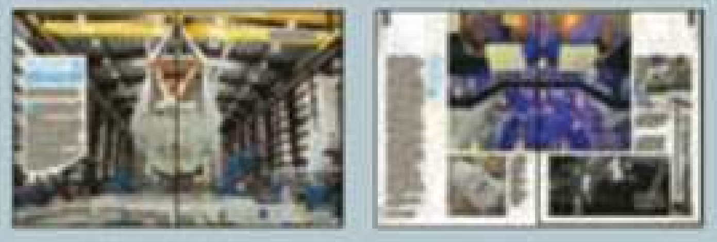


MegaPixel 6
Striking images from the world of science, including a record-breaking bridge

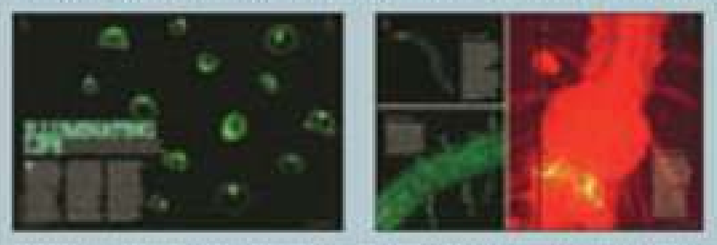
Update 15
The first light from a 'Super-Earth', plus robotic butterflies, mind-reading cash points and more

How to build a brain 32
LEAD STORY The huge effort to recreate the human brain in a supercomputer

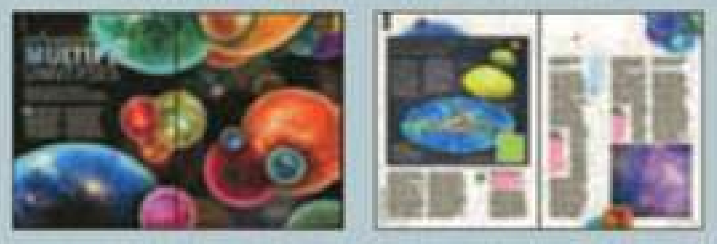
The mind of Alan Turing 40
COVER STORY One hundred years after his birth, we celebrate the achievements of the computer pioneer



Flight of the Dragon 42
We take a look at SpaceX's craft, which heralds a new era of private spaceflight



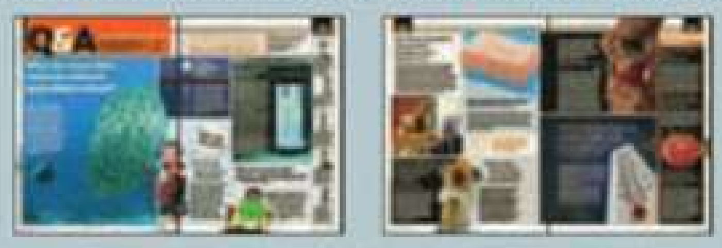
Illuminating life 46
COVER STORY Medical marvel: the amazing properties of the glowing molecule GFP



Hunt for the multiverse 54
COVER STORY Emerging evidence suggests that our Universe isn't alone

Bird watchers 60
COVER STORY How do birds fly? We ask scientists at the 'Flight Lab' to find out

Game changer 64
Fifty years on, computer games are helping science and changing society



Q&A 70
COVER STORY Every month, our team of experts tackle your science questions

Objects of desire 83
The month's latest tech, including the much anticipated Samsung Galaxy S III smartphone

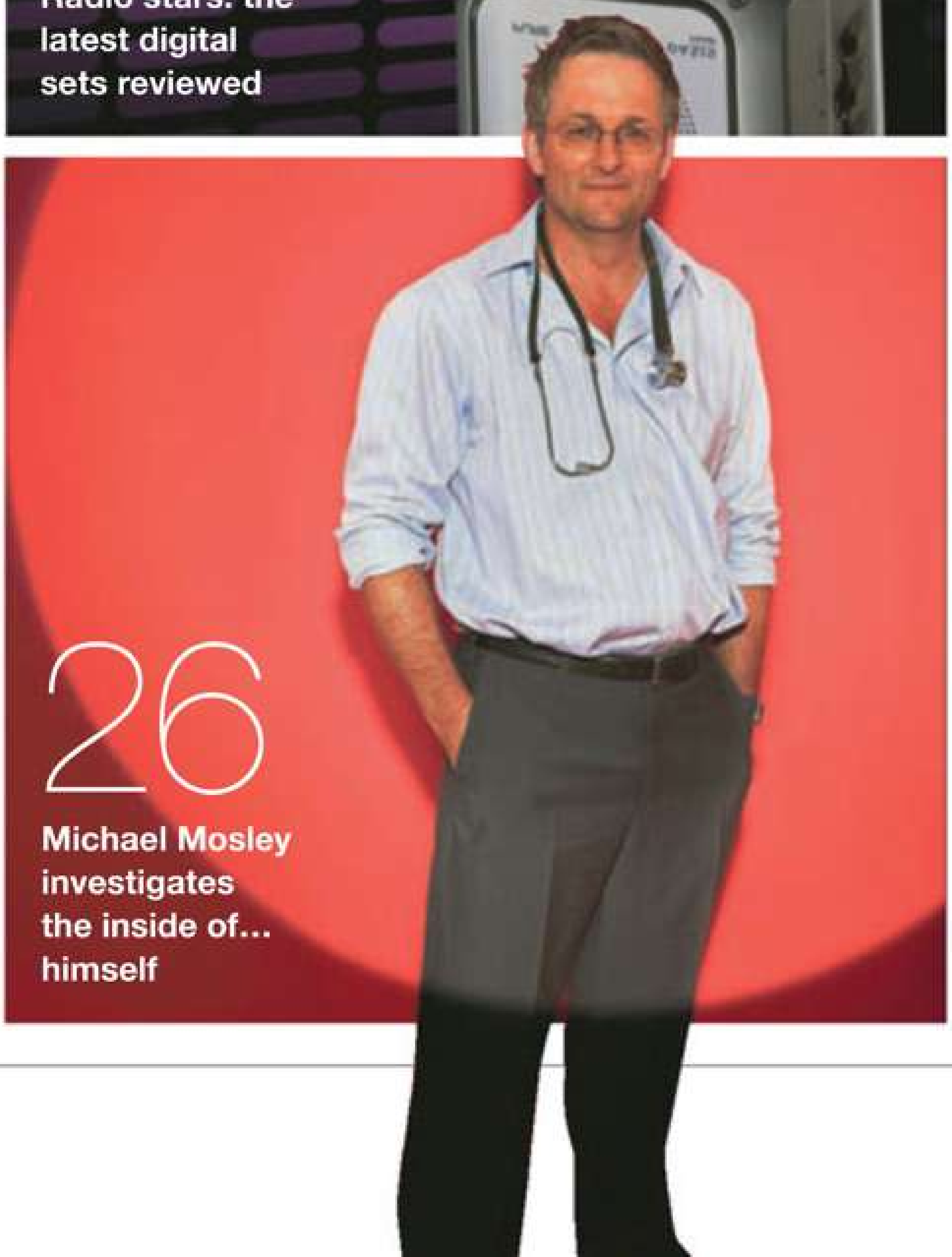
First test: Neurosky 86
Take control of your phone or computer with the power of your mind thanks to this new headset

Tried & Tested 88
Listen to thousands of online stations with one of these digital radios

SUBSCRIBE TO *FOCUS* AND TRY 5 ISSUES FOR £5! 30

54
Scientists are closing in on an incredible discovery: the multiverse

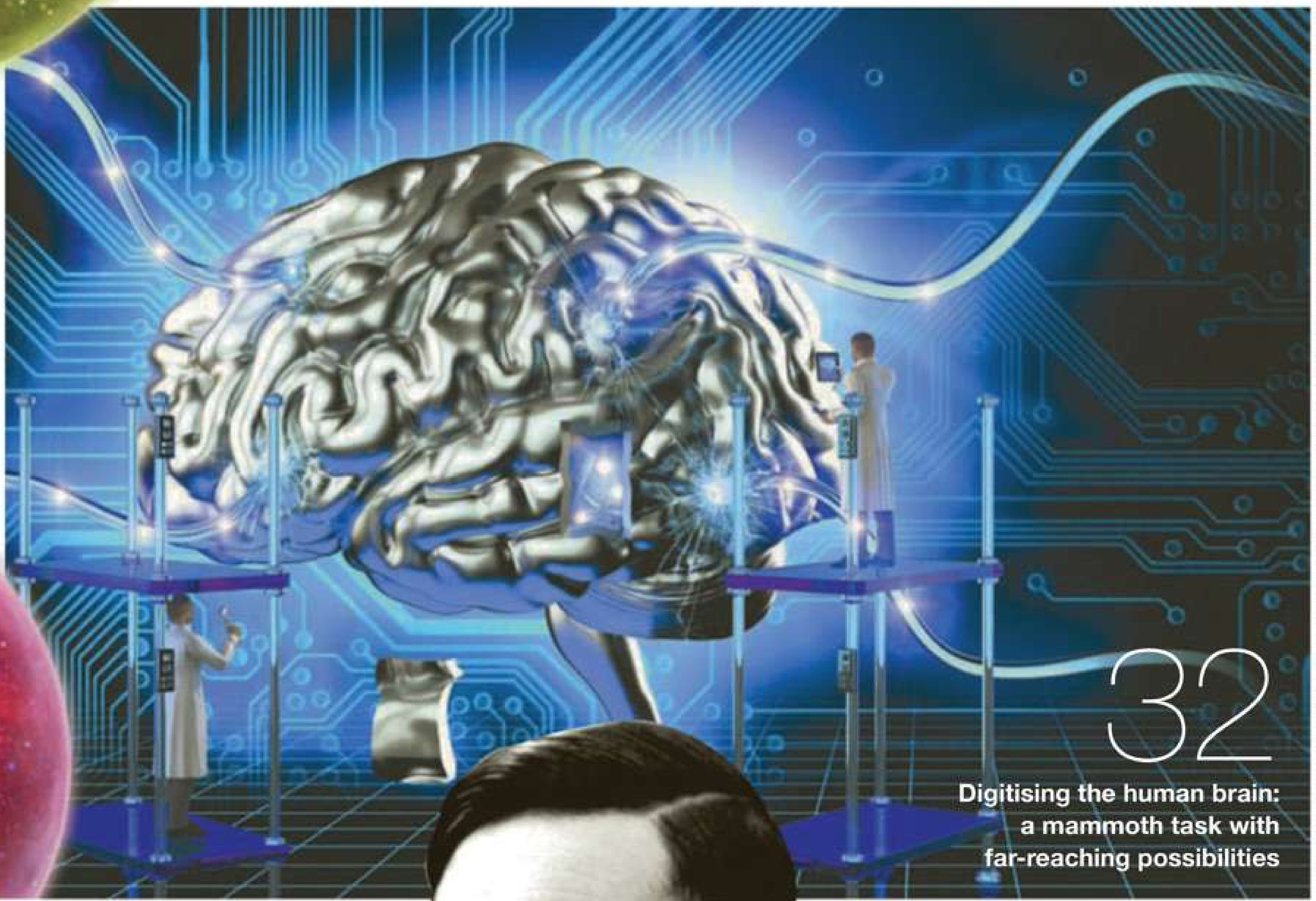
88
Radio stars: the latest digital sets reviewed



26
Michael Mosley investigates the inside of... himself

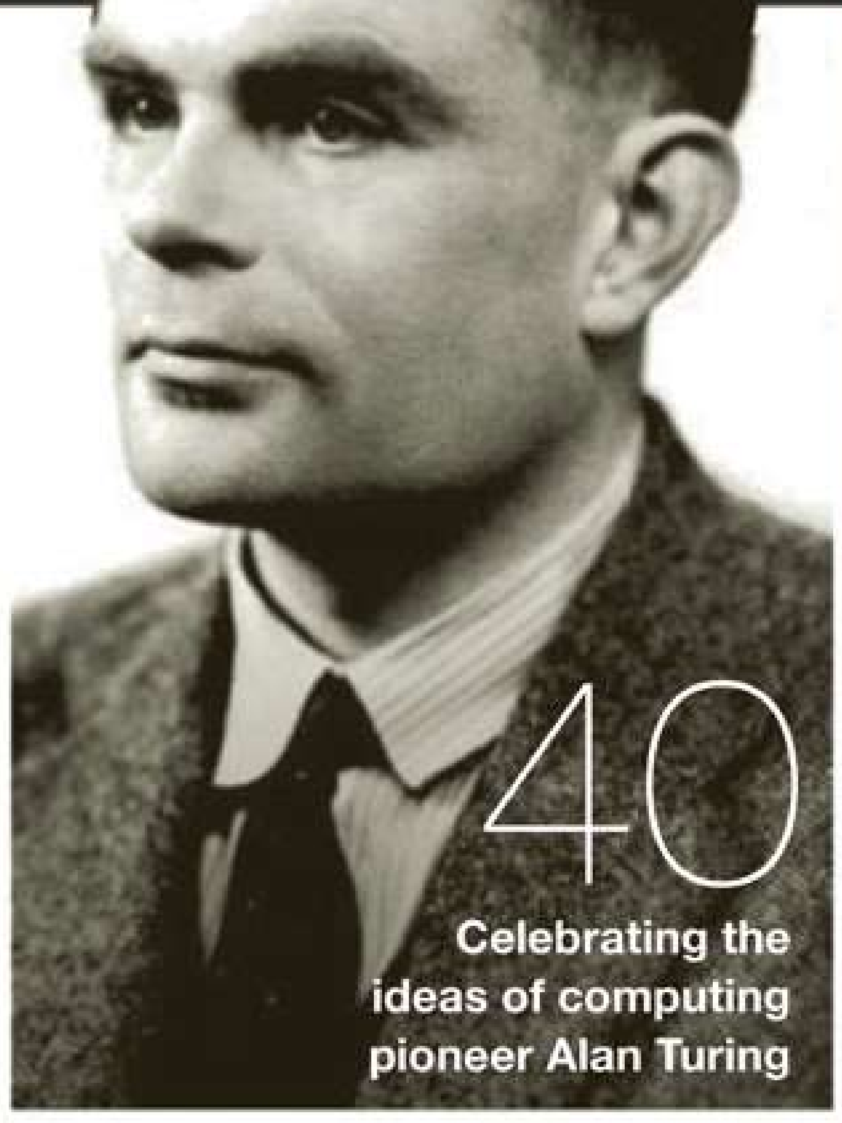
ACUTE GRAPHICS, OLIVER BURSTON, NASA, SCIENCE AND SOCIETY PICTURE LIBRARY, BRET TOBALSKE, MAYO CLINIC, BBC, STUDIO4PHOTO.CO.UK

> *"There's nothing going on in the brain that we can't replicate in silicon"*
>
> **Dr Kwabena Boahen, principal investigator at Stanford University's Brains in Silicon research group, *How to build a brain*, p38**



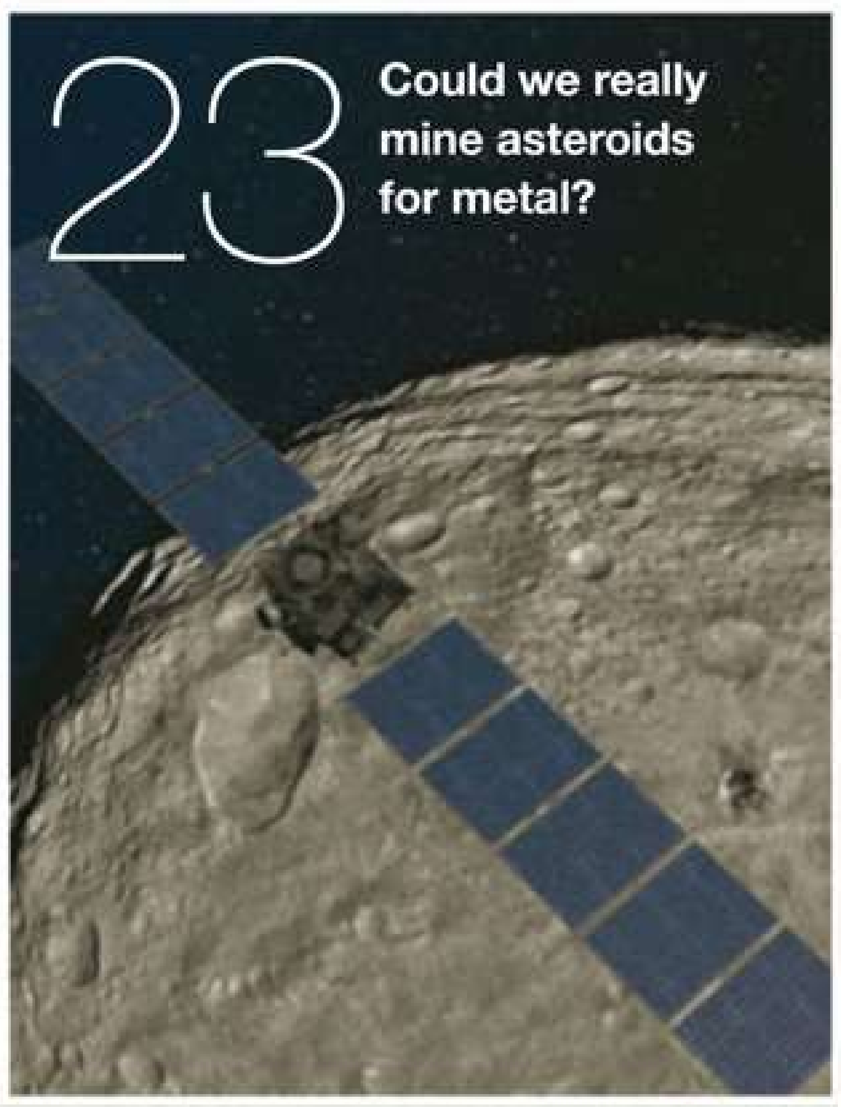
32

Digitising the human brain: a mammoth task with far-reaching possibilities



40

Celebrating the ideas of computing pioneer Alan Turing



23

Could we really mine asteroids for metal?

46

Fluorescent felines: how a glowing molecule has shaped biology

60

The secrets of bird flight revealed

Regulars

Update 15

Post 28

Mindgames 106

Then, Now & Next 114

Q&A 70

Your questions answered

Index

Objects of desire 83

The month's coolest new kit

First test 86

The Neurosky mind-reading app

Tried & Tested 88

Multi-tasking digital radios

Tech Doc 93

Surrendering movement to a robot

Games 94

Resident Evil 6 and more

Web 97

How Facebook can stifle creativity

Books 98

Essential reading for July

What's on 100

Events, exhibitions, talks and TV

F

Magazine
FocusTV
Podcast
App

Sciencefocus.com for competitions and giveaways

Focus TV for video reports and reviews

The Podcast for interviews and gadget news

The app for interactive digital editions

FOLLOW FOCUS

twitter
twitter.com/
sciencefocus

facebook
facebook.com/
sciencefocus

PETE LAWRENCE/DIGITALSKY.ORG.UK

MARTIN OEGGERLI

Sip of the tongue

This is the labellum of a fruit fly, its equivalent of a mouth and tongue, magnified 2,000 times. The labellum forms the tip of a proboscis, the 0.1mm-long tube the fly uses to suck up its liquid lunches. The food first passes through the orange-coloured pseudotracheae (or 'false windpipes') seen here, en-route to the stomach.

The yellow pegs between the pseudotracheae are taste buds that can also be found on other parts of a fly's body. After landing on its favourite food – rotting fruit – the insect will first taste with its feet, which prompts it to extend its proboscis for feeding.

Flies have four types of taste buds, detecting water, sugar, bitter flavours and carbon dioxide. Dr Kristin Scott, a neurobiologist at the University of California, Berkeley, says: "We speculate that CO_2 emitted by growing microorganisms allows flies to find and eat them."

Brush with death

This intrepid worker is dusting off the newly opened Aizhai suspension bridge, which arches over the Dehang Canyon in central China. It holds the record for the longest and highest tunnel-to-tunnel bridge. Below is a 350m drop to the canyon floor – a space big enough to comfortably fit the Eiffel Tower.

To make sure the beams are steady, Dr Zhengqing Chen at Hunan University tested the design of the bridge, which is 1.17km (0.7 miles) long, to its limits. "The main concern for a suspension bridge of this length, high over a canyon, is the risk that it might sway," he says.

"To test the flutter speed – the wind speed at which the bridge would start to move – we created a 12m-long scale model of the structure and the canyon surrounding it to see how wind behaved. Our wind tunnel tests showed that the bridge remains steady at wind speeds up to 110m/s [250mph]." That's far more than the required standard of 50m/s.

REX

EYEVINE

Laser mining

Precision is paramount when you're drilling into the walls of a tunnel in a salt mine. Salt is not as strong as rock, so if the tunnel – or 'gallery' as it's known in the trade – is too large, the walls will simply collapse. Here, in the Realmonte Salt Mine in southern Sicily, a computer-controlled laser guides the operator of a mining machine, ensuring that just the right amount of salt is trimmed from the walls.

"The gallery has to have a certain geometry," says Professor Giovanni Barla at Politecnico di Torino in Italy. The required structure is different for other areas of the mine. "It's determined by the mechanical properties of the salt, the site's geological history and depth," says Barla, who has been investigating the size of the support pillars required at Realmonte.

The salt mined at Realmonte contains too many impurities to be used on food. Instead it's used to keep roads clear of snow and ice.

pcspecialist

/pcspecialist @pcspecialist

Performance you can see and feel.

That's visibly smart.

"Doesn't have much room for expansion but its Blu-ray Drive, 1TB hard disk and great performance make the Enigma HD a Best Buy" - *Barry de la Rosa, Computer Shopper.*

Enigma HD PC

- **2nd Gen Intel® Core™ i5-2400 Processor**
- Genuine Windows 7 Home Premium
- 4GB Samsung DDR3 1333MHz RAM
- 1TB Serial ATA II Hard Drive
- 1GB AMD Radeon HD 6850 Graphics
- 24x Dual Layer DVD-Writer
- 450W Quiet Dual Rail Power Supply
- PCS Black Enigma Case
- 3 Year Silver Warranty

from £549 inc VAT

Take your gaming to the next level with the Xfire X700 PC. With 3rd Gen Intel® Core™ technology and AMD 7 Series Graphics the Xfire X700 will breeze through any task.

Xfire X700 PC

- **3rd Gen Intel® Core™ i5-3550 Processor**
- Genuine Windows 7 Home Premium
- 4GB Samsung DDR3 1333MHz RAM
- 1TB Serial ATA II Hard Drive
- 1GB AMD Radeon HD 7770 Graphics
- 24x Dual Layer DVD-Writer
- 600W Quiet Dual Rail Power Supply
- CoolerMaster Elite 310 Case
- 3 Year Silver Warranty

from £699 inc VAT

The 2nd Gen Intel® Core™ i5-2400 CPU offers excellent value for money. Coupled with the GTX560, this PC will power through all of the latest photo/video editing suites!

Editing V700 Plus PC

- **3rd Gen Intel® Core™ i5-3450 Processor**
- Genuine Windows 7 Home Premium
- 8GB Samsung DDR3 1333MHz RAM
- 1TB Serial ATA II Hard Drive
- 1GB nVidia GeForce GTX 550Ti Graphics
- 24x Dual Layer DVD-Writer
- CoolerMaster Sileo 500 Case
- 24" Widescreen TFT Monitor (1920 x 1080)
- 3 Year Silver Warranty

from £799 inc VAT

Enigma III 540 Laptop

- 15.6" Widescreen Display (1366 x 768)
- Genuine Windows 7 Home Premium
- **2nd Gen Intel® Core™ i5-2450M**
- 4GB Corsair® DDR3 1333MHz RAM
- 500GB WD Scorpio Black SATA II HDD
- 1GB nVidia GeForce GT 540M Graphics
- Gigabit LAN & Wireless N Network Card
- 3 Year Silver Warranty

from £649 inc VAT

The Enigma III 520 is the perfect low-cost gaming laptop. The 2nd Gen Intel Dual Core CPU, 4GB RAM & nVidia Graphics Card makes the Enigma III ideal for portable gaming on a budget!

Optimus II Laptop

- 17.3" Widescreen Display (1920 x 1080)
- Genuine Windows 7 Home Premium
- **2nd Gen Intel® Core™ i7-2670QM Processor**
- 8GB Samsung® DDR3 1333Mhz RAM
- 500GB WD Scorpio Black SATA II HDD
- 1GB nVidia GeForce GT 555M Graphics
- Gigabit LAN & Wireless N Network Card
- 3 Year Silver Warranty

from £799 inc VAT

The 17.3" Optimus II Laptop is fitted with a 2nd Gen Intel® Core™ CPU, massive 8GB RAM & an nVidia Graphics Card! What more could you want under £800?

3 Year Warranty | Flexible Finance Available | Secure Card Payments | Free UK Delivery* | UK Based Call Centre | Trading Over 8 Years | Friendly Forum Community

Prices correct at time of going to press. *Post Code dependent, see our website for details. Intel, the Intel logo, Intel Core and Core Inside are trademarks of Intel Corporation in the U.S. and other countries.

expert REVIEWS 2011 AWARDS BEST PC MANUFACTURER

COMPUTER SHOPPER 2011 AWARDS BEST PC MANUFACTURER

Award winning PCs with the service to match!

PC Specialist Vortex Series

Gaming PCs & Laptops powered by Intel® Core™ Technology.

intel inside CORE i5

intel inside CORE i7

intel inside CORE i7

The 3rd Gen Intel® Core™ CPU combined with nVidia Graphics and a massive 1TB Hard Drive, will keep you one step ahead of the competition!

Vortex 1000 Gaming PC

- **3rd Gen Intel® Core™ i7-3770 Processor**
- Genuine Windows 7 Home Premium
- 8GB Samsung DDR3 1333MHz RAM
- 1TB Serial ATA III Hard Drive
- 1.25GB nVidia GTX 570 Graphics
- 12x BluRay ROM + DVD-RW
- Corsair TX650 Power Supply
- CoolerMaster HAF 912 Case
- 3 Year Silver Warranty

from £999 inc VAT

Take your gaming to the next level with the Vortex 1250 PC. Powered by 3rd Gen Intel® Core™ technology, it'll power through any game you dare throw at it!

Vortex 1250 Gaming PC

- **3rd Gen Intel® Core™ i7-3770 Processor**
- Genuine Windows 7 Home Premium
- 8GB Kingston® Hyper-X 1600Hz RAM
- 80GB Intel 330 SSD + 1TB SATA II HDD
- 2GB AMD Radeon HD7870 Graphics
- 12x BluRay ROM + DVD-RW
- Corsair TX750 Power Supply
- CM Storm Enforcer Gaming Case
- 3 Year Silver Warranty

from £1249 inc VAT

The new 2nd Gen Intel® Core™ i7-3930k is now the benchmark for any new gaming PC. This beast is primed to power through any game out today!

Vortex X79 Extreme PC

- **2nd Gen Intel® Core™ i7-3930K Processor**
- Genuine Windows 7 Home Premium
- 16GB Kingston Hyper-X 1600MHz RAM
- 120GB Intel® 520 SSD + 2TB Seagate HDD
- 2GB nVidia GeForce GTX680 Graphics
- Intel® Certified Liquid CPU Cooler
- Corsair TX850 Power Supply
- CoolerMaster HAF-X Gaming Case
- 3 Year Silver Warranty

from £1949 inc VAT

Vortex III 15 Laptop

- 15.6" Full HD Widescreen Display (1920 x 1080)
- Genuine Windows 7 Home Premium
- **3rd Gen Intel® Core™ i7-3610QM**
- 4GB Samsung® DDR3 1333MHz RAM
- 500GB Seagate Momentus SATA II HDD
- 1.5GB nVidia GeForce GTX670M Graphics
- Gigabit LAN & Wireless N Network Card
- 3 Year Silver Warranty

from £1049 inc VAT

An extremely powerful gaming laptop. The new Ivy Bridge platform which supports the latest Intel® Core™ CPUs and nVidia 6 Series Graphics, the Vortex III is great for every task!

Vortex III 17" Laptop

- 17.3" Full HD Widescreen Display (1920 x 1080)
- Genuine Windows 7 Home Premium
- **3rd Gen Intel® Core™ i7-3610QM Processor**
- 8GB Samsung DDR3 1333MHz RAM
- 120GB Intel® 330 SSD + 500GB SATA III HDD
- 1.5GB nVidia GeForce GTX 675M Graphics
- Gigabit LAN & Wireless N Network Card
- 3 Year Silver Warranty

from £1399 inc VAT

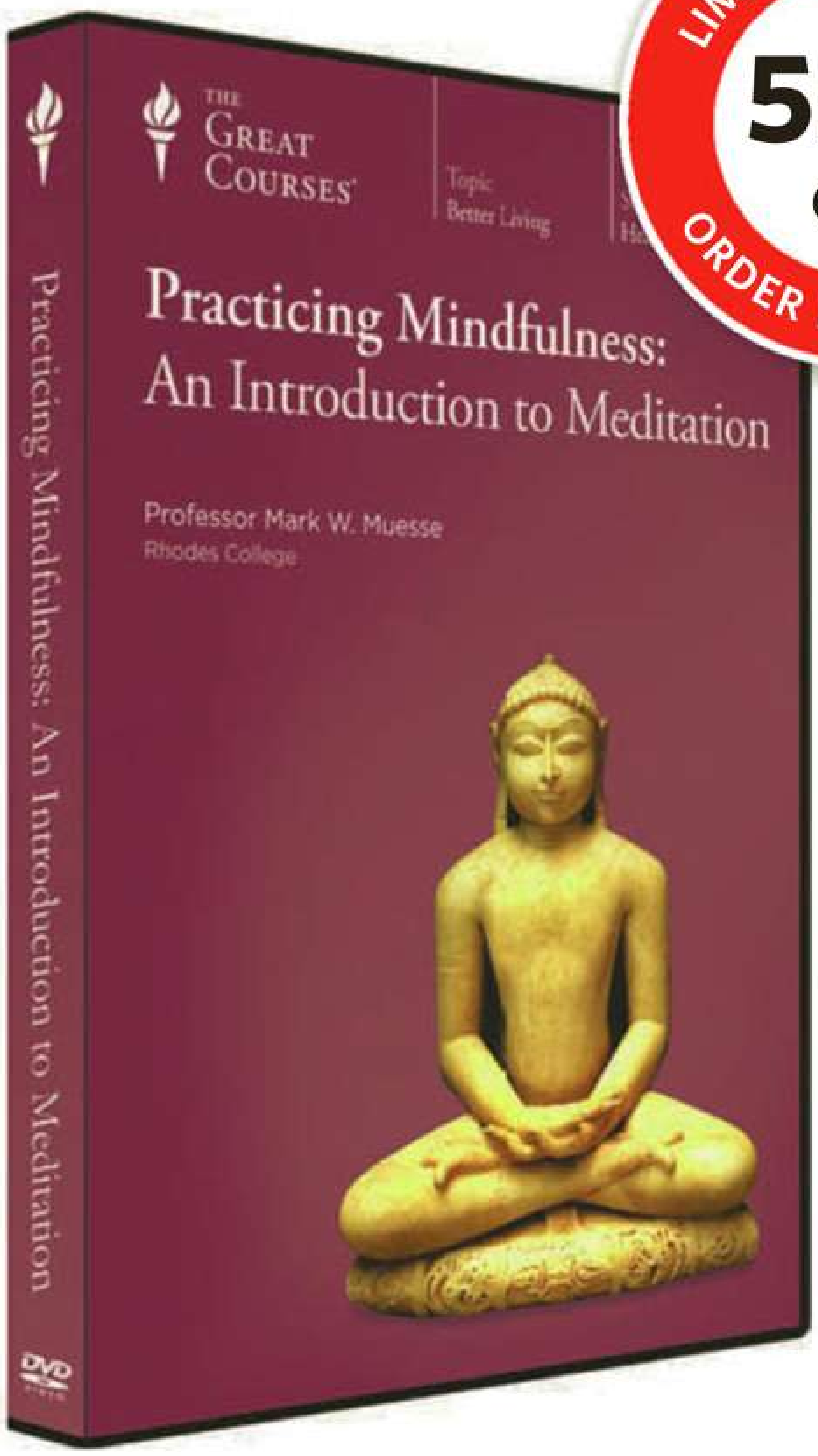
The pinnacle of our gaming laptop range. The Vortex III 17 is based on the new Ivy Bridge platform, supporting the latest Intel® Core™ CPUs and nVidia 6 Series Graphics - gaming heaven!

Save £15 off every order! Enter code BBF29

For the latest technology and most powerful custom PCs & Laptops, call or go online!

0844 499 4000 www.pcspecialist.co.uk

THE
GREAT
COURSES®



LIMITED TIME OFFER
55% off
ORDER BY 29TH JULY

Discover the Essence of Mindful Meditation

In recent decades, science has confirmed that meditation, when correctly practiced, offers lasting benefits for your physical, mental, and emotional health. Now, in **Practicing Mindfulness: An Introduction to Meditation**, experienced meditator and Professor Mark W. Muesse gives you a clear understanding of the essence of meditation—and how best to practice it.

In 24 detailed lectures filled with guided exercises, he teaches you the principles and techniques of sitting meditation, the related practice of walking meditation, the use of meditative awareness in activities such as eating and driving, and more. Emphasizing clarity and practical understanding, his course will leave you with a solid basis for your own practice and for bringing meditation's empowering benefits into every area of your life.

Offer expires 29/07/12

0800 298 9796

WWW.THEGREATCOURSES.CO.UK/5FS

Practicing Mindfulness: An Introduction to Meditation

Taught by Professor Mark W. Muesse
RHODES COLLEGE

LECTURE TITLES

1. Mindlessness—The Default Setting
2. Mindfulness—The Power of Awareness
3. Expectations—Relinquishing Preconceptions
4. Preparation—Taking Moral Inventory
5. Position—Where to Be for Meditation
6. Breathing—Finding a Focus for Attention
7. Problems—Stepping-Stones to Mindfulness
8. Body—Attending to Our Physical Natures
9. Mind—Working with Thoughts
10. Walking—Mindfulness While Moving
11. Consuming—Watching What You Eat
12. Driving—Staying Awake at the Wheel
13. Insight—Clearing the Mind
14. Wisdom—Seeing the World as It Is
15. Compassion—Expressing Fundamental Kindness
16. Imperfection—Embracing Our Flaws
17. Wishing—May All Beings Be Well and Happy
18. Generosity—The Joy of Giving
19. Speech—Training the Tongue
20. Anger—Cooling the Fires of Irritation
21. Pain—Embracing Physical Discomfort
22. Grief—Learning to Accept Loss
23. Finitude—Living in the Face of Death
24. Life—Putting It All in Perspective

Practicing Mindfulness:
An Introduction to Meditation
Course no. 1933 | 24 lectures (30 minutes/lecture)

SAVE UP TO £30

DVD ~~£54.99~~ **NOW £24.99**
CD ~~£35.99~~ **NOW £24.99**
+£2.99 Postage and Packing
Priority Code: 68327

Designed to meet the demand for lifelong learning, The Great Courses is a highly popular series of audio and video lectures led by top professors and experts. Each of our more than 350 courses is an intellectually engaging experience that will change how you think about the world. Since 1990, over 10 million courses have been sold.

The Great Courses®, Unit A, Sovereign Business Park, Brenda Road, Hartlepool, TS251NN. Terms and conditions apply. See www.greatcourses.co.uk for details.

July 2012

Update

The latest intelligence

Need to know

Mind-reading bank machines p17
Facial expressions studied p18
How do pigeons really navigate? p20
Dinosaur pests discovered p22

Robotic butterflies take flight p16

Super-Earth 'seen' for the first time

Detection by NASA space telescope points the way to finding signs of life on alien planets

An artist's impression of the exoplanet 55 Cancri e; its surface temperature is too hot for life as we know it

NASA/JPL

Light from a 'super-Earth' planet outside our Solar System has been detected for the first time. In future, the same technique could be used to sample light from Earth-like worlds and even reveal the tell-tale signs of life (see right).

The exoplanet, 55 Cancri e, has previously been studied by analysing how light from the star it orbits, 55 Cancri, changes as the planet passes in front of it. But now NASA's Spitzer Space Telescope has measured the infrared light coming from the planet itself, providing a much clearer picture of what it's like.

The 55 Cancri system is just 41 light-years from Earth and 55 Cancri e is the closest planet of five to its parent star. It's called a super-Earth due to its size. It's about twice as big as Earth but significantly smaller than gas giant planets like Jupiter. Light from gas giants outside our Solar System has previously been detected, but this is the first light observed from a world that's comparable in size to our own.

55 Cancri e would be a hostile place for humans. Its rocky centre is surrounded by a blanket of steam and its Sun-facing side is a scorching 1,700°C. "We can't see this planet directly; we only know it's there because it passes in front of its parent star and we see a dip in light," says Dr Chris Lintott, an astrophysicist at the University of Oxford and co-presenter of BBC series *The Sky at Night*. "Spitzer has taken advantage of that. It recorded the light from the star when the planet was in the way and took a second measurement when the planet was behind it. When one is subtracted from the other it gets rid of the starlight and you're left with the signature of the planet."

The characteristics of this light reveal what it is like. "The shape of the light spectrum gives you the planet's temperature and colour," says Lintott.

NASA's more sensitive James Webb Space Telescope, scheduled to launch in 2018, will also detect infrared light and could reveal other details about 55 Cancri e. The James Webb telescope could be used to study smaller, potentially habitable planets to see if molecules are present that would reveal the presence of life.

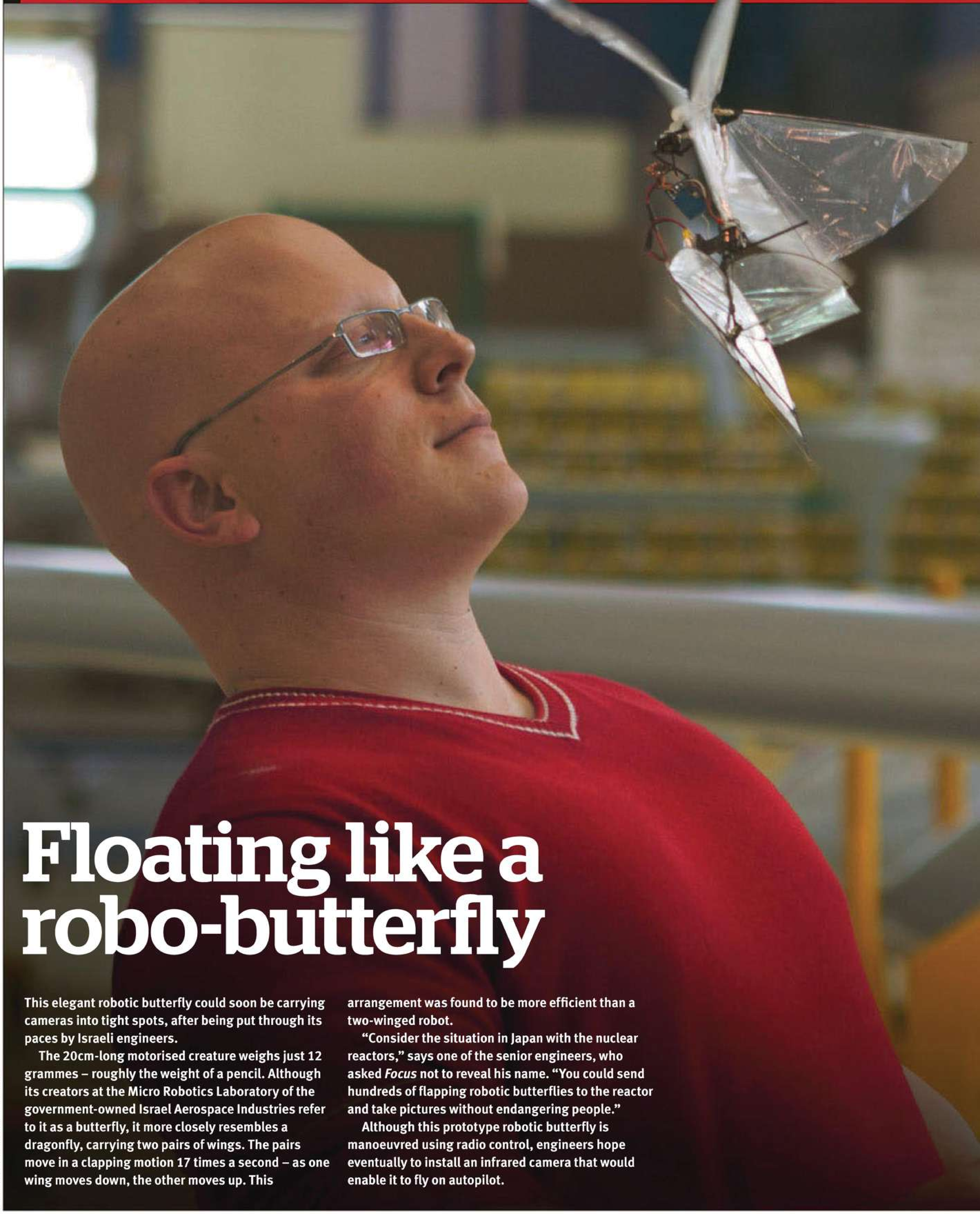
How to find signs of life

What makes this discovery significant is that it's the first time this infrared-detection technique has been used to pick up the light from a rocky 'super Earth'.

Given the right planet, the same technique could reveal the presence of life. "Assuming vegetation on an alien world uses chlorophyll, it would reflect near-infrared light and so you would see a rapid rise in reflectance at these wavelengths," says Dr Chris Lintott.

The technique could also reveal the presence of other molecules, such as water and ammonia, specific levels of which may indicate that life inhabits a planet.

***The Sky at Night*'s Dr Chris Lintott**



Floating like a robo-butterfly

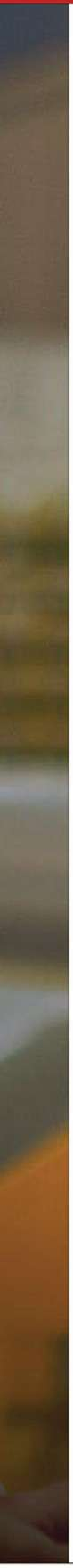
This elegant robotic butterfly could soon be carrying cameras into tight spots, after being put through its paces by Israeli engineers.

The 20cm-long motorised creature weighs just 12 grammes – roughly the weight of a pencil. Although its creators at the Micro Robotics Laboratory of the government-owned Israel Aerospace Industries refer to it as a butterfly, it more closely resembles a dragonfly, carrying two pairs of wings. The pairs move in a clapping motion 17 times a second – as one wing moves down, the other moves up. This arrangement was found to be more efficient than a two-winged robot.

"Consider the situation in Japan with the nuclear reactors," says one of the senior engineers, who asked *Focus* not to reveal his name. "You could send hundreds of flapping robotic butterflies to the reactor and take pictures without endangering people."

Although this prototype robotic butterfly is manoeuvred using radio control, engineers hope eventually to install an infrared camera that would enable it to fly on autopilot.

EYEVINE, THINKSTOCK, ALAMY



MONTH IN NUMBERS

2.5 years

is the delay in mental decline that's been linked to eating blueberries and strawberries in a study of more than 16,000 women. It is thought that antioxidant flavonoids within the fruit are responsible for this effect.

3,000m

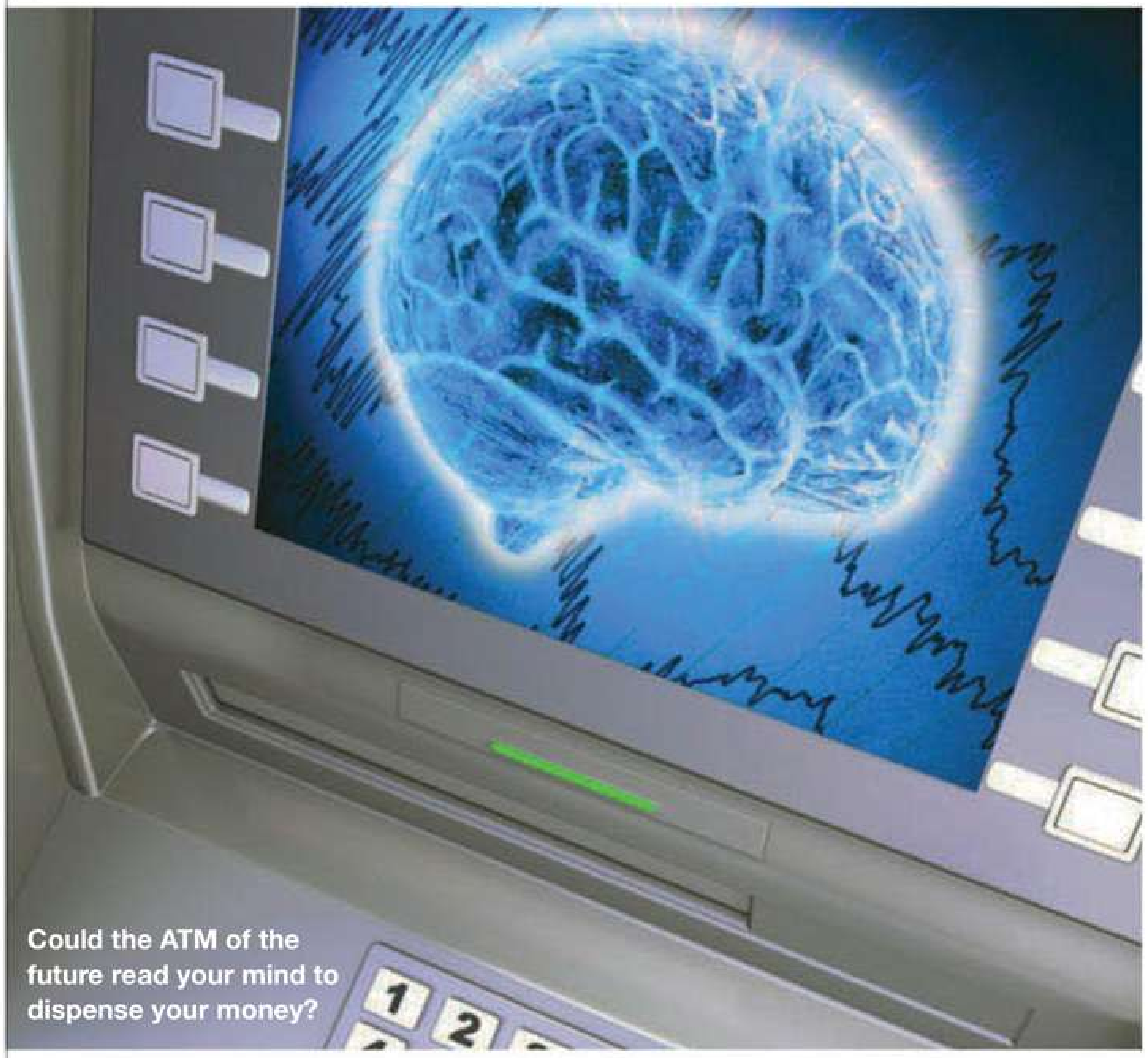
is the distance a new sonic device, being deployed at the Olympic Games, can deliver audible instructions. The Long Range Acoustic Device can also be used to emit a beam of pain-inducing tones at 150dB.

40%

more brain-teasers were correctly solved by volunteers who had drunk the equivalent of two pints of beer than by those who drank no alcohol, in tests at the University of Illinois.

Protect your bank account... ...with your brain

Mind-reading software could replace passwords in new security systems



Could the ATM of the future read your mind to dispense your money?

Typing in pin numbers and passwords could become a thing of the past, thanks to technology that can read your thoughts. A new discovery makes one form of 'cognitive biometrics', as it's known, tougher to crack – bringing it closer to reality.

In cognitive biometrics, the response of your nervous system to a stimulus is measured, then used to identify you. In one form of the technology, a series of letters or images are flashed up on a screen and your P300 wave – a type of electrical activity in the brain – is measured using electrodes fixed to your head. When a pre-defined letter or image (the 'brain word') is shown, recognition by the user generates their 'signature' P300 wave.

Until now, users have been shown different letters or symbols in different parts of a screen. But tests at the universities of Essex, Wolverhampton and Malaya have found that the system identifies individuals most accurately if all characters appear in the same location.

This also reduces the chances of criminals spotting the brain word by tracking eye movement. As there is no keyboard involved, it is much harder for someone intent on fraud to get access to a password. "You still have to keep your password secure," says Dr Palani Ramaswamy of the University of Wolverhampton. "It's just that the way of entering the password is more resistant to fraud."

Accuracy still needs to be improved before cognitive biometrics can come into mainstream use. "Once accuracy is close to 100 per cent, it can be used for financial transactions and maybe high-security military applications as well," says Ramaswamy.

See p86 for gaming technology that can read your mind

A swarm of tiny spacecraft could deflect an asteroid that's on a collision course with Earth, say University of Strathclyde aerospace engineers. They say a 500kg swarm of craft could knock a 250-metre asteroid off course by 35,000km (21,700 miles).

Plant spores can be used instead of chemicals to mop up oil spills. Researchers in Hull have removed the contents of spores and modified their outer shells to create hollow spheres that can trap up to 3.5 times their own weight in oil.

A chemical gel is being developed at the University of Birmingham that may increase male fertility by improving the swimming prowess of sperm.

GOOD NEWS

BAD NEWS

All contact has been lost with Envisat, a climate-monitoring satellite launched in 2002. The craft is the largest non-military craft put into orbit, providing data on the land, oceans and ice. The European Space Agency had hoped that the satellite, which has cost £2.1bn so far, would continue operating until 2014.

A lack of shut-eye increases your chances of gaining weight. A detailed analysis of several studies found strong evidence that less than six hours sleep each night can lead to obesity. Sleep loss affects the secretion of hormones which regulate appetite and feelings of satiation.

More than 1,000 dead pelicans have been washed up on the Pacific coast of Peru. The cause of the deaths is being investigated.

INSIGHT

Reactionware

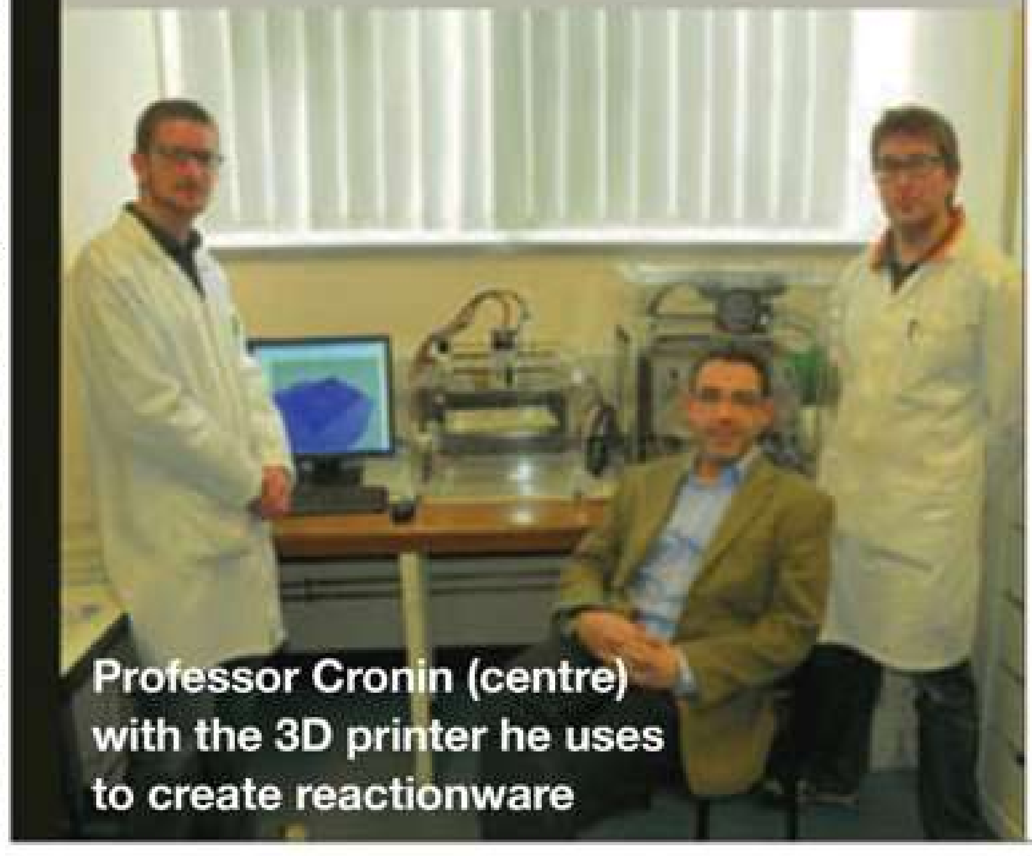
What's that?
It's the name given to some special vessels in which chemical reactions take place. They're special because they can be created to a scientist's own design using a 3D printer.

How is that different?
For the last 200 years, chemistry experiments have been done in vessels that are a fixed shape. But reactionware can be printed in the shape required to study a given reaction. The vessel walls can also be impregnated with a catalyst to speed up the reaction, or electrodes to monitor what's going on.

What's so exciting about that?
With reactionware it's easy and cheap to make custom vessels, opening up new avenues of research. And because the whole reaction is self-contained, reactionware could be safely used outside of a lab. Personal pharmacies could produce medication in our homes just by downloading an app. The technology could also be used to produce medicines in Third World countries.

What's it made of?
The chemists at Glasgow University behind reactionware build the vessels using the same silicone sealant that you can buy in DIY shops. When it's time to start a reaction, they pierce holes in the upper chambers so the reagents flow into the main reaction chamber below.

So what's next?
Different materials are being tested to see whether they would be more resistant to the caustic conditions created by some chemical reactions.


Professor Cronin (centre) with the 3D printer he uses to create reactionware

T BOLCH/UNIVERSITY OF ZURICH/TU DRESDEN, NASA, GETTY, CHRISTINE PULLIAM/CFA, UNIVERSITY OF GLASGOW

ROUND UP

This month's top science stories from around the globe

GENETICS

Horse taming traced

Horses were domesticated 6,000 years ago in modern-day Ukraine and West Kazakhstan, a genetic study shows. Horses have been interbred and their wild ancestor, *Equus ferus*, is extinct, making their history difficult to follow. The international team of researchers studied the DNA of over 300 horses from the region and compared the results with computer simulations of horse domestication. The best fit was a model that has horses being domesticated in the Eurasian Steppe.

NANOTECHNOLOGY

New wonder stuff created

Step aside graphene, there's a new kid on the nanotech block – silicene. Researchers in Germany, France and Italy have created the new material, a single layer of silicon atoms, by condensing silicon vapour onto a silver plate. Graphene, a single layer of carbon atoms, has been heralded as a wonder material. Silicene is thought to have the same electronic properties as graphene but could be more readily integrated into electronic components, as many are already made from silicon.

ANTHROPOLOGY

Darwin wrong about faces

Charles Darwin originally posited the view that facial expressions are universal across cultures, but psychologists at the University of Glasgow have found that this isn't the case. The team showed Western and east Asian people animations of faces and found that Westerners had no problem distinguishing surprise, fear, disgust and anger. However, Asians confused fear with surprise, and disgust with anger. The results show that Asians may be using different cues to read these emotions.

ENVIRONMENT

Maverick glaciers gain ice

While most of Earth's glaciers shed ice as global temperatures rise, it seems a minority are gaining weight. French glaciologists used data from space-based instruments to investigate glacier changes in the Karakoram – a mountain range straddling the borders of China, India and Pakistan. They found that glaciers here gained mass between 1999 and 2008. The cause of this unusual behaviour is not yet understood, but there are indications that the region's climate is cooling.

HEALTH

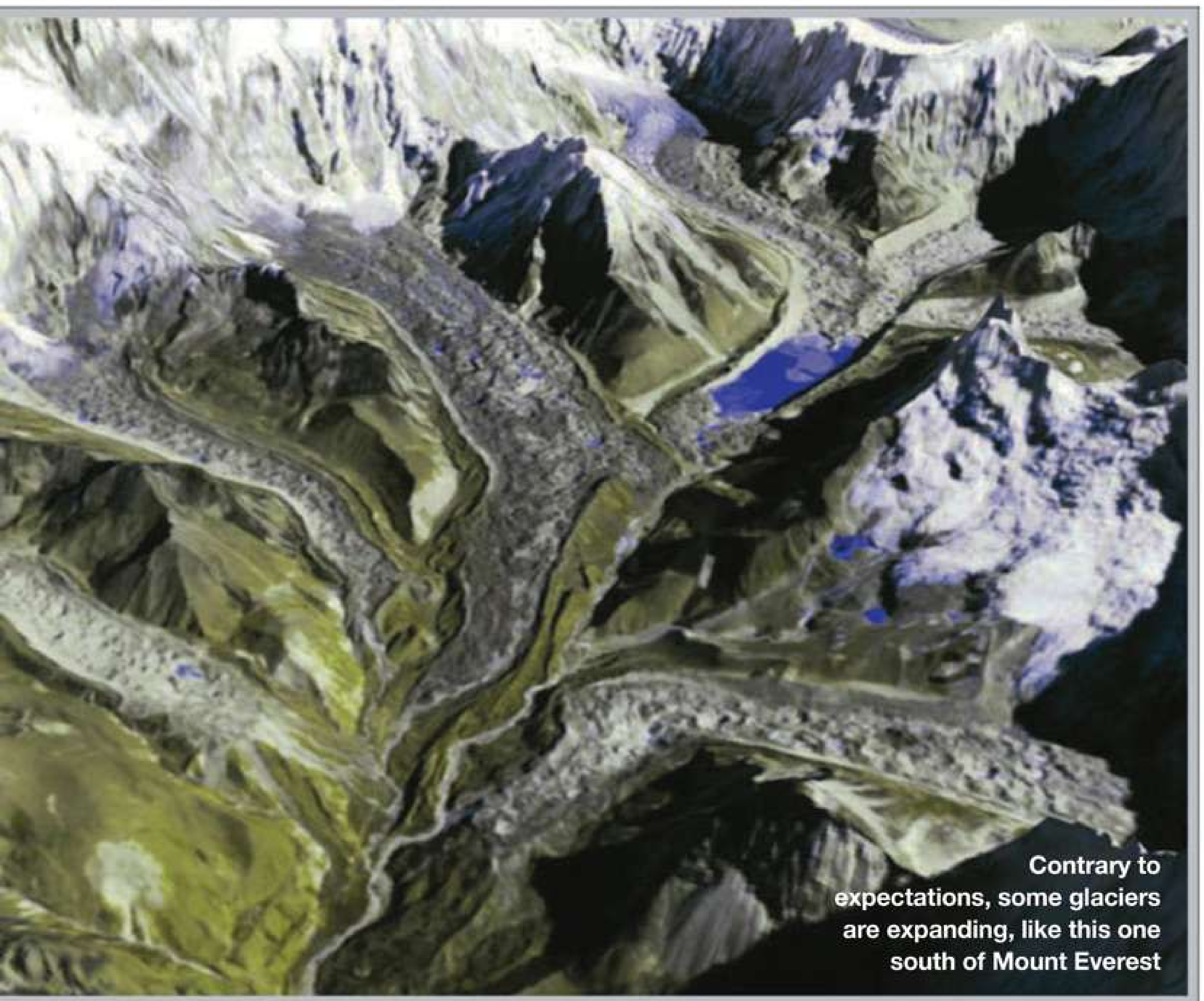
Sponges help cancer fight

Chemicals found in ocean sponges could stop cancer cells becoming resistant to drug treatment. Lamellarins help sponges defend themselves against marine competitors, and scientists at the University of Queensland found that some inhibit P-glycoprotein, a gene product that can cause cancer cells to resist treatment by pumping out anti cancer-drugs. They investigated 16 of these chemicals recovered from sponges collected off the coast of Australia.

NEUROSCIENCE

Motivation mystery unlocked

How hard we are willing to work is influenced by the chemistry of our brains. Scans carried out at Vanderbilt University in Tennessee show that go-getters release more of the neurotransmitter dopamine in the striatum and the ventromedial prefrontal cortex – brain regions that play an important role in reward and motivation. In contrast, slackers have high dopamine levels in the anterior insula, which is involved in emotion and risk perception. The research shows that dopamine has different effects on different parts of the brain.



Contrary to expectations, some glaciers are expanding, like this one south of Mount Everest

PALAEONTOLOGY

Mini mammoth roamed island

The smallest mammoth ever known would have lived on the island of Crete, say palaeontologists. The remains of a creature which would have stood about 1m tall were first discovered in 1904, but have now been re-examined by experts at the Natural History Museum in London. Characteristic patterns on the teeth show that the animal is not a descendent of the extinct straight-tusked elephant *Palaeoloxodon antiquus*, as had been expected. The creature has been named *Mammuthus creticus*.

ASTRONOMY

Nomadic worlds captured

Billions of stars in our Galaxy may have captured 'rogue' planets that were roaming freely around space after being kicked out of the star systems in which they originally formed. Astronomers in the US and China simulated young star clusters and found that if the number of rogue planets equals the number of stars, between three and six per cent of stars captured a planet over time. No clear-cut cases of captured planets have been identified yet, but astronomers are busy looking for them.

The Milky Way could be home to many former 'rogue' planets

MARTIAN INTRIGUE

An international team of scientists and mathematicians has taken a fresh look at data from 36 years ago and concluded that NASA might have found life on Mars after all.

The Viking robots, sent to Mars in 1976, scooped up soil samples from the Martian surface before processing them to hunt for signs of microbial life. The general consensus was that geological rather than biological activity was all that they found.

But in the new study, the data was analysed mathematically for complexity – the premise being that biological systems are more complicated than non-biological ones. Crucially, the researchers found similarities between the Viking results and the data that was generated by biology on Earth.

The findings are certainly not conclusive proof of life on Mars, but are worthy of further investigation, says the team.

NEWS IN BRIEF

- A lack of contact with the natural environment is giving city-dwellers allergies such as hayfever. Scientists at the University of Helsinki collected samples of bacteria from the skin of over 100 teenagers and found that those living on farms or near forests had a more diverse community of gammaproteobacteria. This class of bacteria is important for maintaining the immune system, influencing the production of anti-inflammatory proteins called cytokines.

- The human head can fit through the birth canal because the cranial bones aren't fused. A new study shows this delayed fusion was also seen in early humans that lived nearly three million years ago. Anthropologists studied the metopic suture, the joint between the two frontal bones in the cranium, in several early humans. Among those studied was that of Taung child, a four-year-old *Australopithecus africanus* that lived almost three million years ago in South Africa.

- A 'dolphin speaker' built at Tokyo University will provide a new way to study the marine mammals. Dolphins can hear and produce sounds below 20kHz, which humans can hear, but also high frequency sounds at up to 150kHz that we can't. The researchers found there were no speakers that could project such a range of frequencies, so they made their own, with a 7-170kHz range.

- Flatulent dinosaurs would have had a significant effect on the Mesozoic climate, say biologists. Calculations show that long-necked sauropods alone, some of the biggest dinosaurs, could have produced more methane than natural and man-made sources put together. It's thought that sauropods, like cows, harboured methane-producing bacteria that helped them digest the plants they ate.

Dinosaur flatulence may have changed the climate

An MRI scan reveals fine detail in a pigeon's beak – tissue is purple and bone yellow

Pigeon navigation gets more mysterious

The iron-rich cells in pigeons' beaks, previously thought to play a key role in their incredible powers of navigation, have been found to be nothing more than immune cells, incapable of relaying information to their brain. "By looking at the structure and immunological properties of these iron-containing cells, it was shown that they were actually macrophages, not the required neuronal tissue," says Dr Jeremy Shaw at the University of Western Australia, who worked on the project.

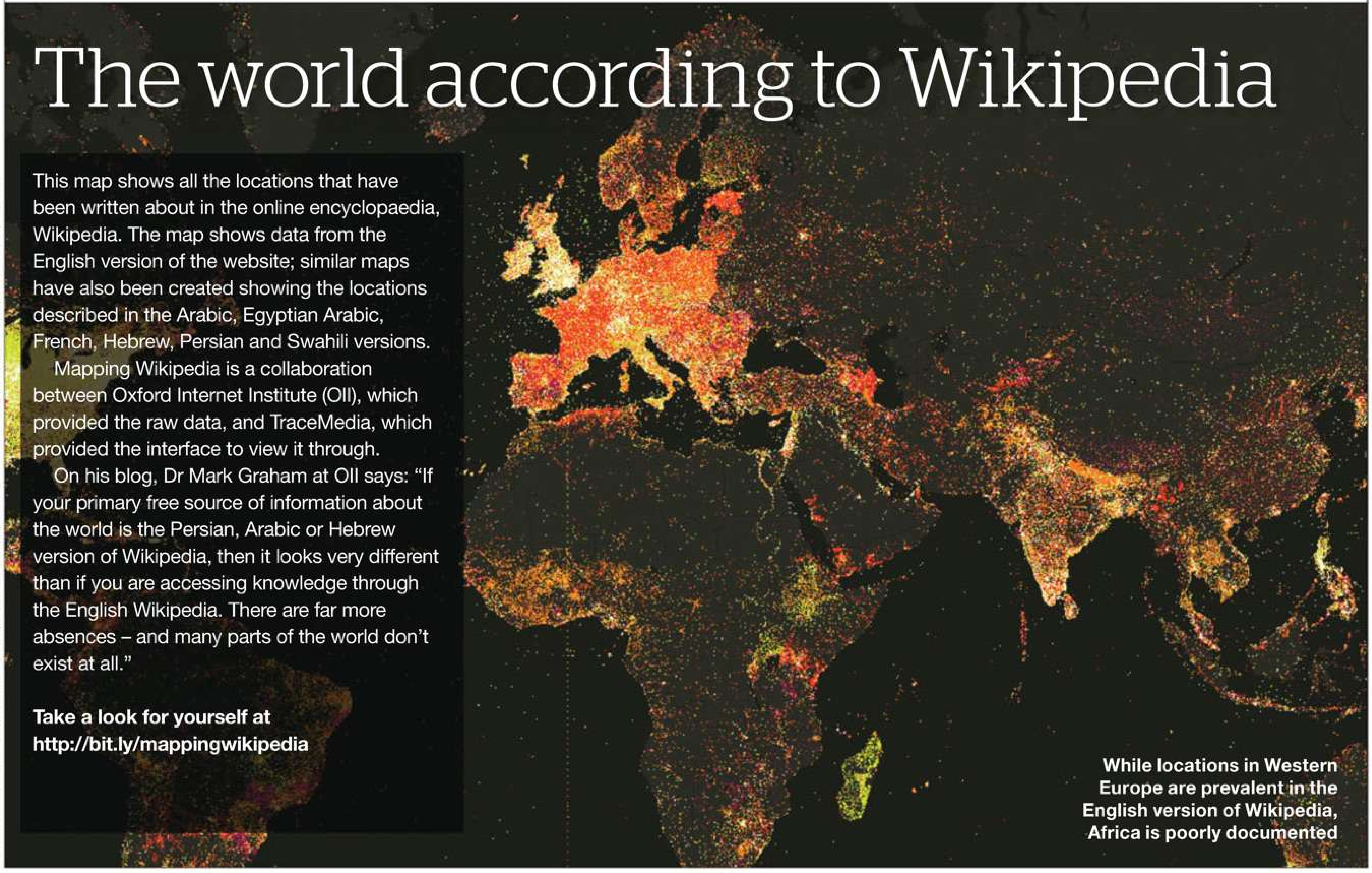
Macrophages help the body fight off infections, as well as recycling iron from red blood cells. Crucially, they cannot produce electrical signals and so would not be capable of alerting a bird to a change in magnetic field. The discovery means the search is back on for the magnetic field-sensing nerve cells.

"It's not an easy task," says Dr David Keays of the Research Institute of Molecular Pathology in Vienna, who led the research team. "Trying to find the magnetoreceptors is not just like trying to find a needle in a haystack – it's like trying to find a needle in a haystack made of needles!"

Scientists have known for some time that pigeons can sense magnetic fields, and that tiny particles of iron oxide, called magnetite, reside in the beak. Using high-resolution imaging techniques on over 200 birds, an international team of scientists including experts at the UCL Centre for Advanced Biomedical Imaging in London studied the internal structure of the beak in unprecedented detail.

In separate research, neuroscientists in the US have identified cells in pigeons' brain stems which record the direction and strength of the magnetic field. It is thought that this information is then compared to a stored map. But the location of this map, like that of the nerve cells which do the initial sensing, is unknown.

The world according to Wikipedia



This map shows all the locations that have been written about in the online encyclopaedia, Wikipedia. The map shows data from the English version of the website; similar maps have also been created showing the locations described in the Arabic, Egyptian Arabic, French, Hebrew, Persian and Swahili versions.

Mapping Wikipedia is a collaboration between Oxford Internet Institute (OII), which provided the raw data, and TraceMedia, which provided the interface to view it through.

On his blog, Dr Mark Graham at OII says: "If your primary free source of information about the world is the Persian, Arabic or Hebrew version of Wikipedia, then it looks very different than if you are accessing knowledge through the English Wikipedia. There are far more absences – and many parts of the world don't exist at all."

Take a look for yourself at http://bit.ly/mappingwikipedia

While locations in Western Europe are prevalent in the English version of Wikipedia, Africa is poorly documented

MARK LYTHGOE/UCL CABI, MARK GRAHAM/OXFORD INTERNET INSTITUTE & GAVIN BAILY/TRACEMEDIA

TRUSTED HERE.

AND TO FIND THE QUICKEST WAY TO THE AIRPORT.

FREE LIFETIME MAPS & TRAFFIC*

Trust Garmin to have the most up-to-date maps and 3D Traffic FREE for the life of your sat nav. Roads change, bridges are built and traffic delays come and go, but with Garmin you know you've always got the latest picture of the roads without paying more. Ever.

garmin.co.uk/lifetime

GARMIN.

SAT NAV FROM THE WORLD'S GPS EXPERT.
TRUSTED EVERYWHERE.

*Selected sat navs only. See website for details.

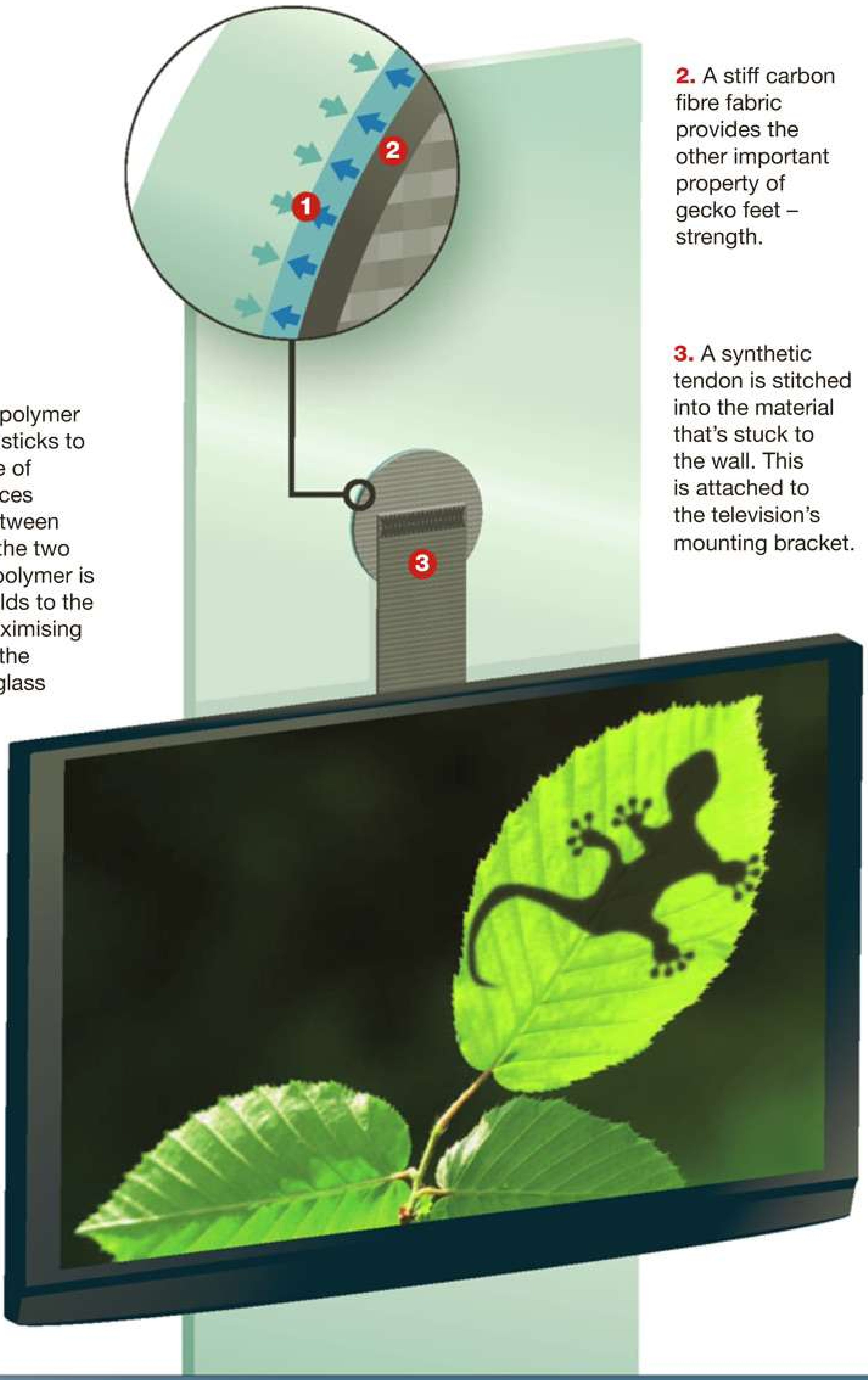
Gecko-inspired sticky tape can hold up a TV

The ability of geckos to run up walls has fascinated biologists for years. Now a gecko-inspired sticky tape has been developed that could do everything from sticking a TV to a wall to holding parts of a car together.

Not only is 'Geckskin' incredibly sticky stuff – capable of fixing 300kg to a flat surface – it can also be released with a gentle tug, and reused over 100 times without losing its strength.

Previous attempts to construct such an adhesive focused on mimicking the microscopic hairs that cover gecko toes. But it proved difficult to make larger pieces of these fabrics. Instead Geckskin, developed at the University of Massachusetts, Amhurst, employs other properties of gecko feet to impart its sticking ability – it is incredibly tough while being flexible enough to make close contact with whatever surface it's sticking to.

In a demonstration of its abilities, the material was used to fix a 42-inch flatscreen TV to a glass surface.



1. A thin rubbery polymer layer in Geckskin sticks to the glass because of van der Waals forces – an attraction between the molecules of the two surfaces. As the polymer is so flexible, it moulds to the glass surface, maximising contact between the molecules in the glass and polymer.

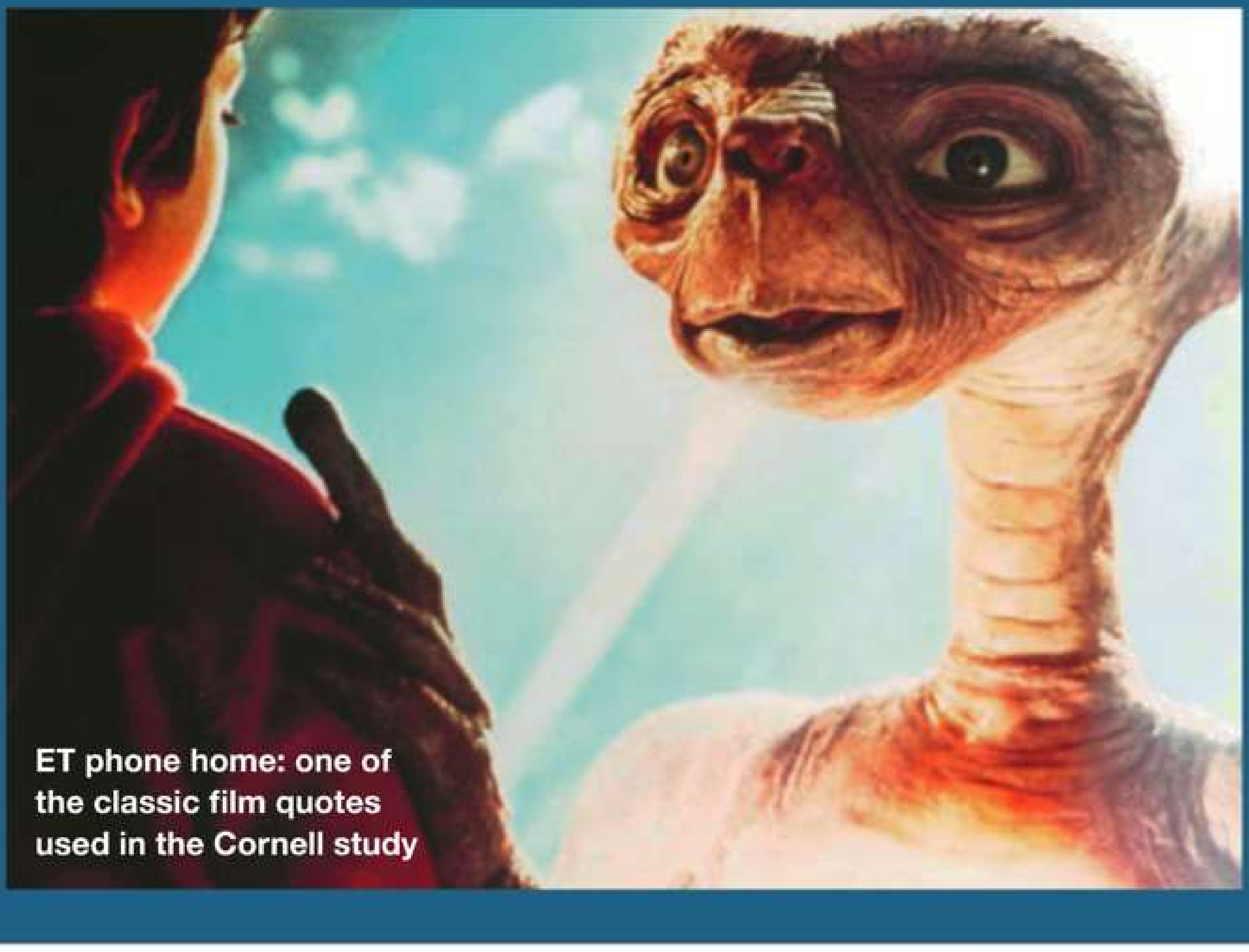
2. A stiff carbon fibre fabric provides the other important property of gecko feet – strength.

3. A synthetic tendon is stitched into the material that's stuck to the wall. This is attached to the television's mounting bracket.

...and finally

Computers spot movie magic

Classic lines from films can stick in all our minds. And it seems computers can recognise them, too. Computer scientist Cristian Danescu-Niculescu-Mizil at Cornell University in the US compiled a list of quotes and paired each with an 'ordinary' line. Software was able to identify characteristics, such as surprising word combinations, peculiar to memorable lines. After a while, the computer could distinguish memorable and non-memorable lines with a 68 per cent accuracy.



ET phone home: one of the classic film quotes used in the Cornell study

Prehistoric pests discovered

If you spend the summer batting away insects, spare a thought for dinosaurs – they were doing the same thing 165 million years ago. Fossils of two giant flea species have been found in Inner Mongolia by Chinese biologists. The insects lived when creatures such as the feathered dinosaur *Epidexipteryx hui* were around to be their hosts. They sported claws long enough to reach over dinosaur scales and the larger of the two, *Pseudopulex magnus*, had mouthparts 5.2mm long.

NASA, UNIVERSAL/KOBAL COLLECTION, RICHARDPALMERGRAPHICS.COM

THE BURNING QUESTION

Dr John Brophy is an expert on space propulsion at California Institute of Technology's Jet Propulsion Laboratory, who co-led an asteroid retrieval study

With John Brophy

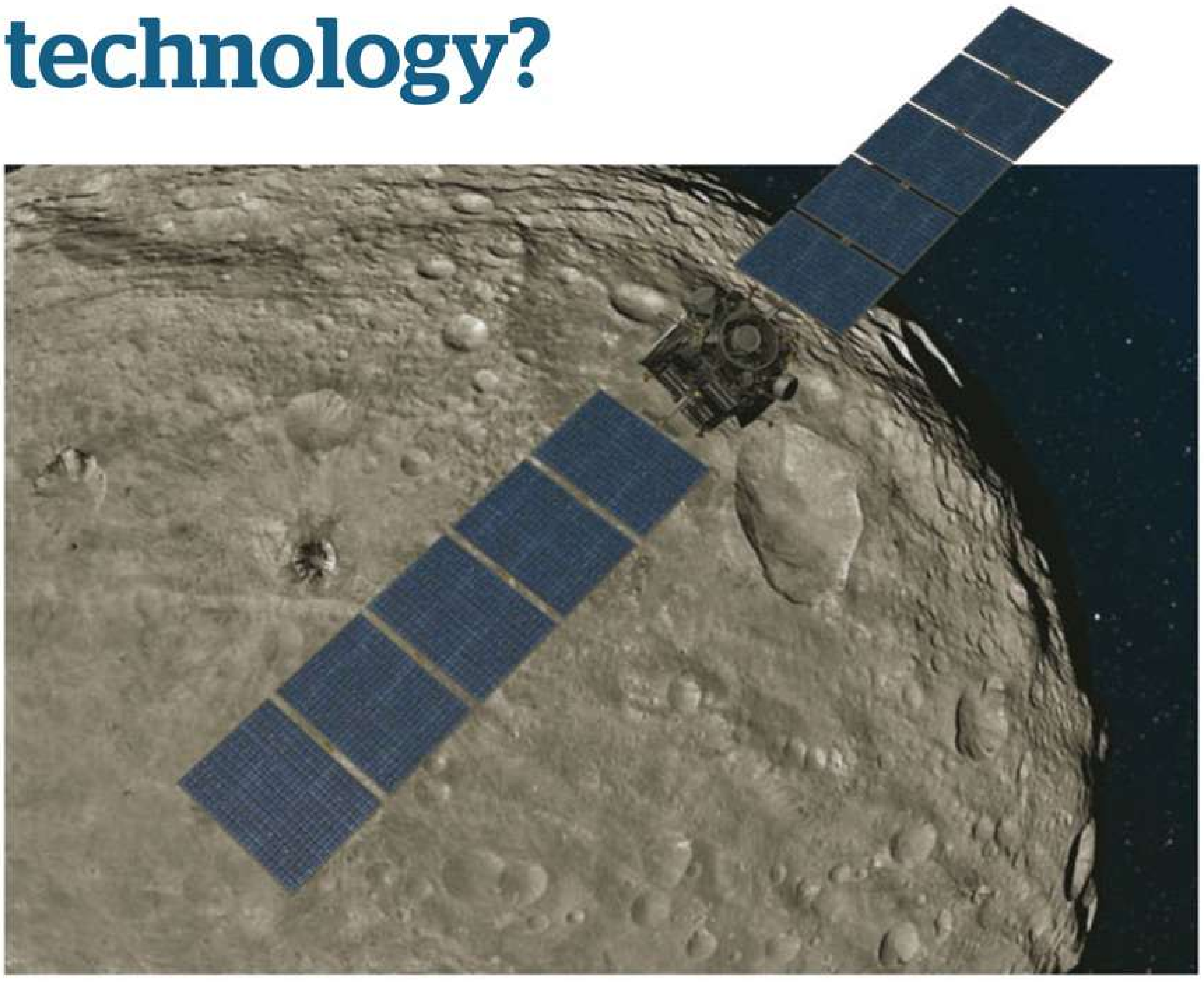
Could we mine asteroids using current technology?

The news that a company called Planetary Resources is planning to mine asteroids might sound like something from the pages of a science-fiction novel, but it's actually a story that recently appeared in the business sections of news outlets around the world. But although the company is backed by an impressive list of billionaires, including Google CEO Larry Page and former Microsoft chief architect Charles Simonyi, many people are wondering whether mining an asteroid is actually achievable.

The idea to exploit the natural resources of asteroids is older than the space programme. In 1903, Soviet rocket scientist Konstantin Tsiolkovsky included the "exploitation of asteroids" as one of his 14 points for the conquest of space. So what's different about today that suggests this is now possible?

When most people think about asteroid mining, if they think about it at all, they probably envision mining in the main asteroid belt, located between Mars and Jupiter. But the Solar System is much messier than the one you learned about in school. A key aspect of this messiness is that there are hundreds of millions of so-called near-Earth objects. These are asteroids and comets whose orbits are roughly the same distance from the Sun as Earth's. It is this population of objects that are the most accessible for mining.

There are three basic approaches to asteroid mining. 1) Mine and process the material at the asteroid and return only the processed material. 2) Mine the asteroid and return the raw material for processing. 3) Return an entire small asteroid for processing. The first approach would require a very high degree of automation and/or the presence of humans, so is unlikely to be used. The second and third approaches would require less sophisticated automation, and were the subject of a recent study by the Keck Institute for Space Studies. This study estimated the cost of an asteroid return mission at $2.6 billion (£1.6bn).



"Initially, the most valuable extracted material will be water"

To return an entire near-Earth asteroid, a robotic spacecraft would rendezvous with it in deep space, where it would determine its size, shape and rotation state. The spacecraft would then match its rotation, drive over it, and capture it in a high-strength bag, cinching the bag closed in a manner similar to closing a large rubbish bag. The spacecraft would then de-spin the asteroid and transport it to lunar orbit.

Transportation is the key, and that's what's different today. For the first time in history, space propulsion technology is up to the task, and that technology is solar electric propulsion, which is 10 times more fuel-efficient than the best chemical rockets. A low-power, 2.5kW version is currently in use on NASA's Dawn mission. A spacecraft with a more powerful 40kW system could be launched by the end of this decade and return a 7m diameter, 500-tonne asteroid to lunar orbit by around 2025. Bringing back such an object would provide significant quantities of valuable resources, enabling human exploration farther out into the Solar System.

Asteroids contain a variety of materials of interest for high-tech industrial applications, including platinum-group metals and semiconductor materials such as gallium, germanium, selenium and tellurium. To use these materials for terrestrial applications, however, requires their transport to the Earth's surface – a very difficult undertaking that will likely push such endeavours well into the future.

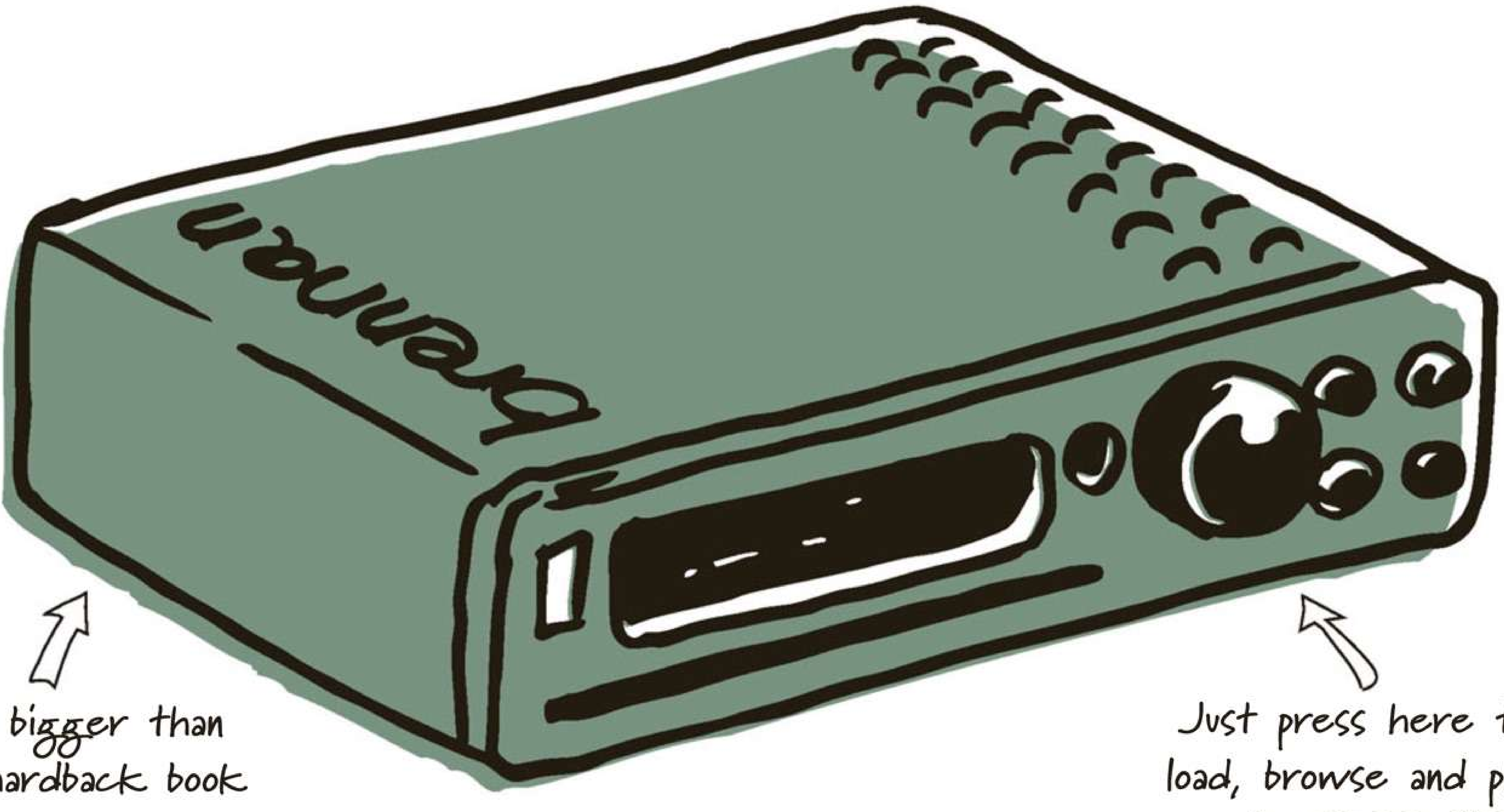
Initially, the most valuable extracted material will be water for use in space. The water itself could be used to provide enough material to shield against hazardous radiation from cosmic rays. Such radiation is a potential show-stopper for human exploration beyond low-Earth orbit, but asteroid mining could provide the solution. So the answer is yes: asteroid mining is not only feasible, it may revolutionise space exploration.

WHAT DO YOU THINK?

Should we mine asteroids for their mineral resources, or leave them untouched?

post@sciencefocus.com

Makes listening to your music simple again.

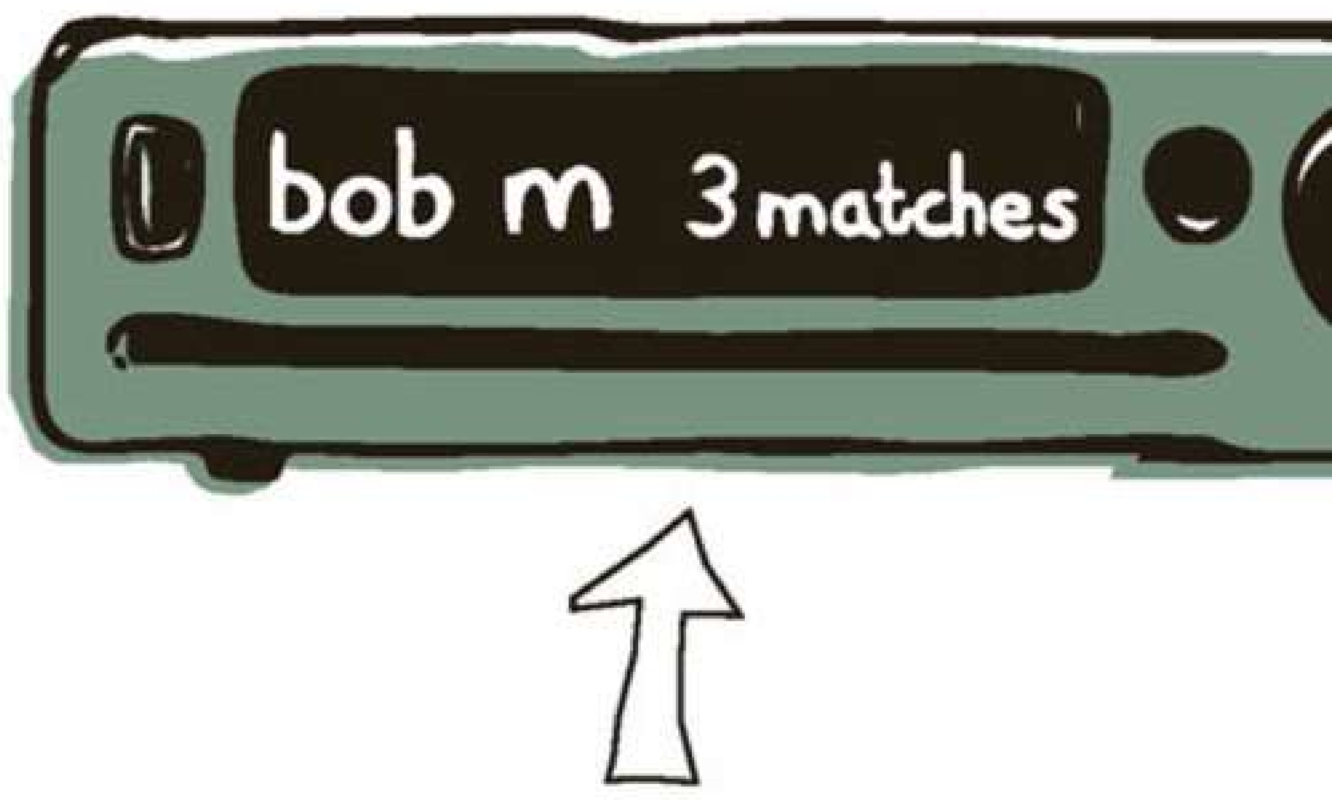

brennan
No bigger than a hardback book
Just press here to load, browse and play up to 5000 CDs

How many CD's do you own but never play? 100s? 1000s? If you're like most people your CD collection has grown and grown over the years but listening to it has got less and less. What was once a simple pleasure has become so much hassle you don't bother. Trying to find the CD you want amongst a sea of CD cases. Opening it up only to find it's got the wrong CD in it. Having to listen to several tracks you don't particularly like until you get to one of your all time favourites. No wonder your music eventually gets left on the shelf, forgotten, unloved.

Well now, thanks to the revolutionary Brennan JB7, listening to your CD collection just got simple again. No more searching, no more frustration – just every album and track that has meant so much to you over the years available at the touch of a button.

No bigger than a hardback book, the Brennan JB7 enables you to store, browse and listen to up to 5000 CDs. Loading each CD onto its built-in hard drive takes just 3-4 minutes, album and track names are automatically recognised and finding them again using the remote control takes just seconds. The Brennan JB7 will even pick your music for you and play it back in a random combination that will surprise, entertain, amuse and even move you in a way you would never have imagined.

Additional features include the ability to record from vinyl, cassette or radio, play MP3 downloads, create your own colour coded playlists and a segue function that blends one track into the next.


bob m 3matches
Find the music you want to hear in just seconds

Clever, eh?

Voted 'Best Buy' by Gramophone Magazine, What Hi-Fi and Sunday Times, they all agree there's nothing quite like the amazing Brennan JB7. Experience it for yourself and if you don't concur we'll refund your money – no questions asked.

Only available direct, for more details and to place your order simply visit www.brennan.co.uk.

A WORD ABOUT COPYRIGHT In 2006 the record companies said unequivocally that they are happy for you to load your own CDs onto a hard disk but the Advertising Standards Authority have asked us to tell you that it is unlawful to copy material without the permission of the copyright holder.

brennan

The Analyst

Robert Matthews

If you're a scientist, failing to stick with the pack can cost you your job

Now and then I enjoy having a gamble, so I always appreciate top tips. And here's one I'm happy to share with you. If you're offered a bet on whether Einstein has been proved wrong by a team of scientists, put your money on the old guy with the crazy hair. Einstein is even more reliable than the double Cheltenham Gold Cup winner Kauto Star – and, it would seem, those scientists said to have found neutrinos travelling faster than light.

I couldn't find anyone willing to take my money when that story broke. Maybe I shouldn't have said in this column that the idea was probably cobblers. It was certainly a long shot – and now it's been shot down. Apparently some dodgy wiring and a problem with a timer simply created the illusion that neutrinos could travel faster than light.

Yet as any serious gambler will tell you, long shots are worth taking a punt on – if the payoff is big enough. They don't often pay off, but when they do, they more than make up for all the losses.

There was a time when scientists also backed occasional long shots, investigating some weird stuff on the off-chance it would pay off. And sometimes it did. Tiny discrepancies in the orbit of Mercury noted by Victorian astronomers revealed flaws in Newton's law of gravity, while the fogging of photographic plates discovered by Henri Becquerel in 1896 turned out to be an early hint that $E = mc^2$, as Einstein showed some years later.

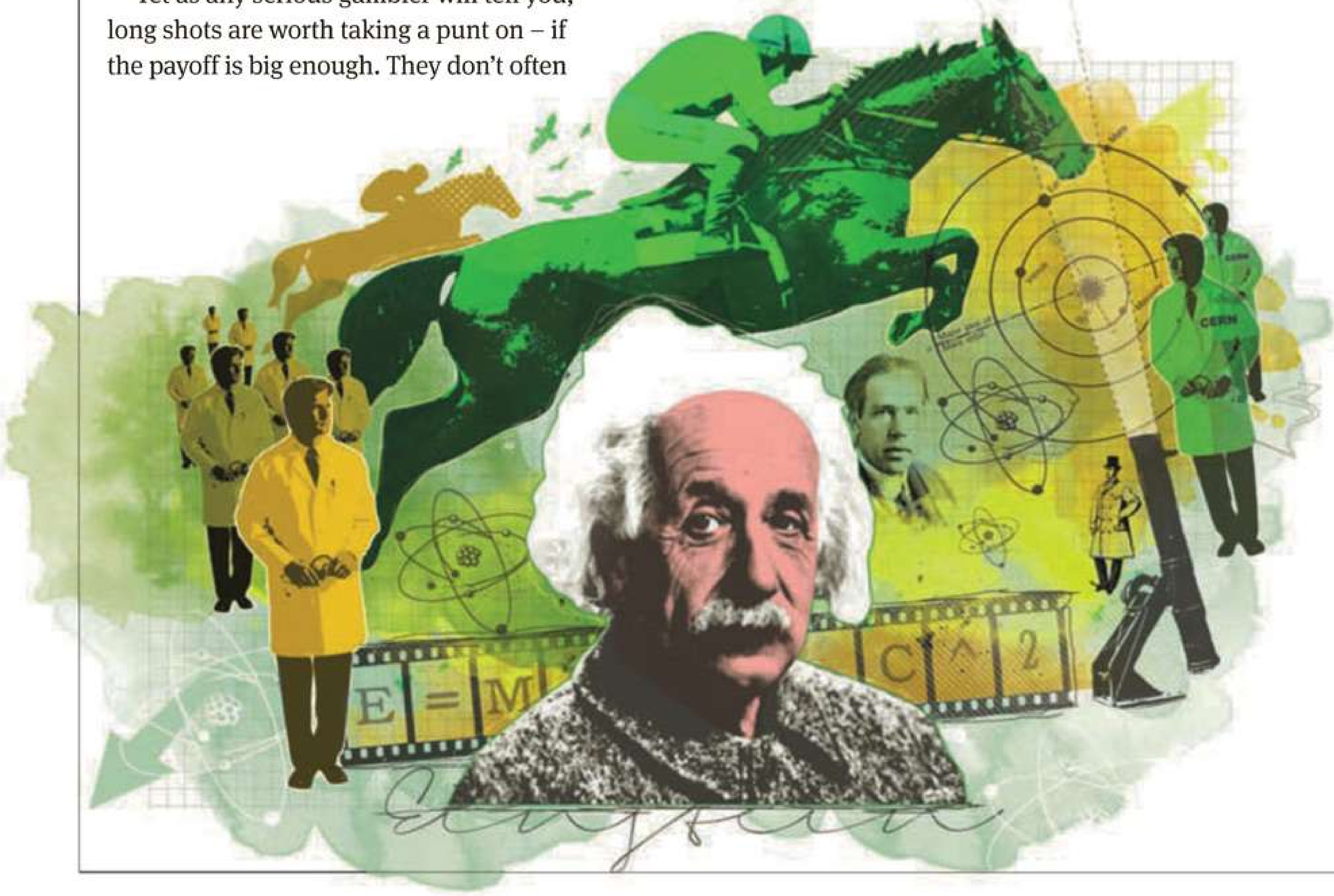
Yet when the team at CERN in Geneva announced some weird measurements of the speed of neutrinos, the response was depressing. The media predictably over-reacted, but many researchers appeared very keen to stick the boot in. Maybe they never read beyond the headlines, but they seemed to think the CERN team were insisting Einstein was wrong and were in the pub waiting for the Nobel Committee to call. In reality, the team never claimed to have 'discovered' anything. They just wanted other researchers to help find out what was really going on, which is kind of what science is supposedly about.

> *"They just wanted other researchers to help find out what was going on, which is what science is supposedly about"*

Sure, there were very good reasons for being suspicious, but they weren't knock-out disproofs. Such things exist in maths, but not in science, where the only way forward is to collect more evidence.

Yet even when other researchers did take up the challenge set by the CERN team, they too showed depressing symptoms of forgetting what science is about. Announcing their findings, their spokesperson declared they were "100 per cent sure" that neutrinos don't travel faster than the speed of light. Really? Not the slightest chance of being in error? Of course, they didn't really mean that (at least, I hope not). What I suspect they meant was: "We're 100 per cent sure we agree with mainstream opinion" – which is the nice, warm place all too many scientists like to be. And who can blame them? The furore over the experiment led to its leaders having to step down.

There's an irony in all this. The discovery of the neutrino itself came about through attempts to understand odd experimental results in the 1930s. These baffled even the great Niels Bohr, one of the most revered scientists of the time. Yet he was prepared to consider the possibility that perhaps the basic laws of physics needed altering to explain the strange findings. In the event, Bohr's radical solution proved unnecessary; even so, he wasn't ridiculed by his peers or forced out of his job. Sadly, it seems anyone even hinting at harbouring such thoughts today can expect no such support.



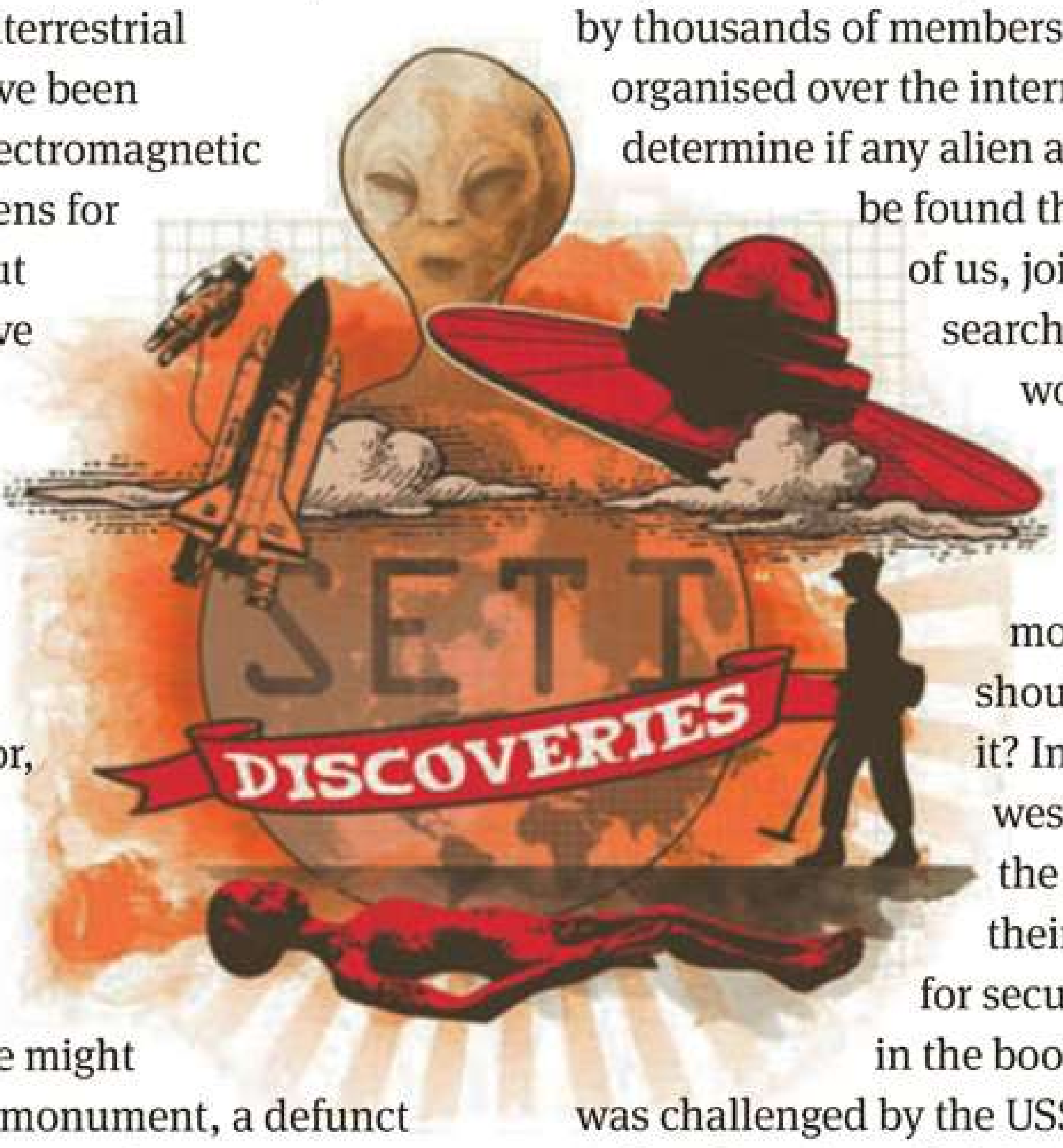
DANHILLIARD.CO.UK

The Futurist **Stephen Baxter**

Crowd-sourcing the search for alien relics

One of the lead characters in Ridley Scott's new movie *Prometheus* is an archaeologist, bent on investigating the remains of an interstellar culture. This is fiction, but perhaps it contains a glimpse of the real future of our search for alien civilisations.

Scientists involved with SETI (the Search for Extraterrestrial Intelligence) have been searching for electromagnetic signals from aliens for 50 years, without success. Nor have we convincing evidence of direct contact – a visit by ETI. But what if we found, not a signal or a visitor, but an artefact? Given what we ourselves have deposited on other worlds, we might expect to find a monument, a defunct probe or even a waste dump.



Where might we look? Alien artefacts might be preserved for millions of years in geologically 'stable' places on Earth, such as central Australia. Searches have been made in the archaeological and historic archives without success. Another possibility is the surface of the Moon. The most famous alien artefacts in science fiction are the monoliths of Clarke's *2001: A Space Odyssey*, one of which was buried on the Moon. There are even stable locations in space, such as the Lagrange points of gravitational equilibrium between Earth and the Moon, where objects can reside for long periods.

Modern orbital probes and landers, such as ESA's Mars Express and NASA's Mars rovers are equipped to map planetary surfaces with high-resolution cameras and explore subsurfaces with instruments like radar. Physicist Paul Davies of Arizona University recently suggested using crowd-sourcing to search for evidence of alien artefacts on the Moon. The Lunar Reconnaissance Orbiter will return a million images of the Moon's surface by the time its mission is complete. A systematic scrutiny of these images by thousands of members of the public, organised over the internet, could determine if any alien artefacts wait to be found there. Any one of us, joining in such a search, could make the world-shattering discovery.

But suppose we did find a monolith. What should we do with it? In Clarke's *2001*, western powers hid the discovery of their lunar monolith for security reasons; in the book's sequels this was challenged by the USSR as illegal. In fact there is no definition of the legal status in human society of an ETI artefact.

There are questions of security too. As the heroes of *Prometheus* find out, an alien artefact can turn out to be pretty nasty! Even with a benevolent artefact there may be issues of contamination or toxicity; quarantine may be advisable. A brutal possibility is to destroy such an artefact when and if there is a chance to do it, even though it violates scientists' instincts. Perhaps, before the event, we need to think about how to manage such a find for the benefit of all mankind, maybe under a controlling UN commission.

DANHILLIARD.CO.UK

WHAT DO YOU THINK?

What do you think the human race should do if we come across an alien artefact?

post@sciencefocus.com

MEET THE COLUMNISTS

The Futurist
Stephen Baxter

A pre-eminent science-fiction writer and regular *Focus* contributor, his books include *The Science Of Avatar* and the popular *Destiny's Children* series.

The Insider
Henry Gee

A senior editor of the respected science journal *Nature*, Henry is the author of several books, including *The Science Of Middle Earth*.

The Eco-sceptic
Tom Heap

Tom is an expert on all things green. He presents *Panorama* on BBC One and *Costing The Earth* on Radio 4, which questions accepted truths on green issues.

The Analyst
Robert Matthews

After studying physics at Oxford University, Robert became a science writer. He is a visiting reader in science at Aston University.

The Medic
Michael Mosley

After training as a doctor, Michael joined the BBC to become a presenter, writer and producer. He's *The One Show*'s science man and presented *The Story Of Science*.

The Medic **Michael Mosley**

Seeing my own insides was enlightening

If I had known what it involved I would have thought longer and harder before agreeing. But my interest had been piqued. How often do you get the chance to become a living exhibit at the Science Museum in London? Or watch the passage of food through your intestines in front of a few hundred enthusiastic spectators?

The world contained within our intestines is a dark, dank, curious and alien one. Down there live bacteria that have never seen the light of day, a rich diversity of life akin to a rainforest. These bacteria impact on our health in ways that we are only just beginning to explore.

Not many of us get a chance to see that world, let alone share the experience with others. So when the controller of BBC Four, Richard Klein, asked me to swallow a camera pill as part of a film about the intestines, I said 'yes'. I fasted for 24 hours, drank four litres of laxative the night before, and then, bright and early made my way to the Science Museum. My companion for the day was gastroenterologist Dr Mark McAlindon, one of the UK's leading pill camera experts. He is rather more used to having patients swallow cameras for diagnostic purposes, but was game to try it on a healthy volunteer.

The day went well and I learnt many surprising things about my intestines, including the fact that the guts are lined with a 'second brain' whose job is to control the gastrointestinal system. It's called the enteric system and contains as many neurons as you would find in the brain of a cat. The images were extraordinary and you'll be able to see them on *Inside Michael Mosley* on BBC Four in July.

I came away hugely impressed with the complexity of our digestive system. And as for the camera, well it worked its way out. Or at least I think it has. I haven't been checking.

BBC FOUR

Watch *Inside Michael Mosley* in July on BBC Four. For dates and times check out RadioTimes.com

BY APPOINTMENT TO
HER MAJESTY THE QUEEN
SUPPLIERS & MANUFACTURERS
OF RADIO AND TELEVISION
ROBERTS RADIO LIMITED

BY APPOINTMENT TO
H.R.H. THE PRINCE OF WALES
MANUFACTURERS & SUPPLIERS
OF RADIO RECEIVERS
ROBERTS RADIO LIMITED

ROBERTS

www.robertsradio.co.uk

www.facebook.com/roberts.radio

FOR STOCKISTS CALL: 01709 571722

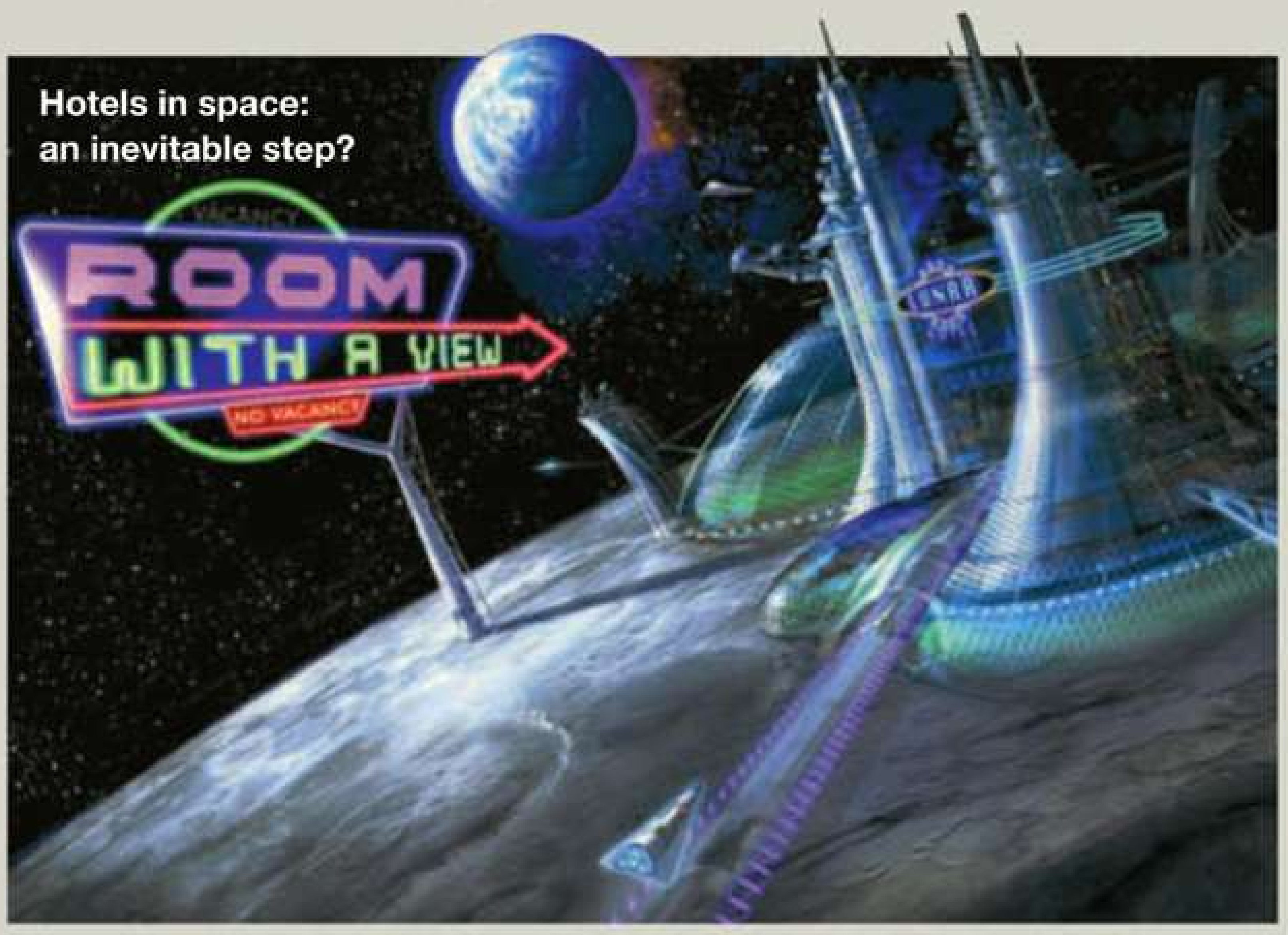
Your *Letters*

Write in and Win

Message of the month

The letter of the month writer wins a copy of *Paradox* by Jim Al-Khalili worth £16.99, courtesy of Bantam Press

Space tourism pioneers


Hotels in space: an inevitable step?

One of the aspects of space tourism, as touched on in your May edition ('Room with a view', p46), is that there is a certain 'inflationary' pressure. People always want to go one step further, from leaving the atmosphere to moving away from Earth.

The first party of Europeans to visit the Grand Canyon suggested that theirs would probably be the only group of colonists ever to visit such an out-of-the-way, inhospitable location. Nowadays the Grand Canyon is a major tourist attraction. Improvements in transport and communications, together with the increase in population, have brought this about.

There has long been speculation that living in a lower-gravity environment could extend the human life span. If a number of billionaires became convinced that living in orbit, or on a lunar colony, could add a couple of decades to their lives, then we might see a flood of investment towards a 'retirement community', either in orbit or on the Moon. Some of your readers may have come across Robert A Heinlein's story, *Waldo*, in which a millionaire entrepreneur, suffering from a degenerative disease, sets up home in a satellite providing a zero-gravity environment.

The news, just published, of Google's Larry Page and Eric Schmidt, together with film director James Cameron, forming a company with the aim of mining asteroids, introduces a whole new aspect to the question of space exploration and habitation. It appears that the actual mining will be carried out by robots. However, it is quite possible that there may be manned complexes in orbit to process the material brought back.

As the members of that first expedition to the Grand Canyon would no doubt agree, once you have blazed a trail into new territory, you leave it open for others to follow.

Peter Davey, Bournemouth

What's cute?

I accept that we are programmed to prefer cute features so that we will protect the survival of our species, by being driven to protect and nurture infants (April, p55). But does this not imply that babies and small children would prefer looking at adult features, as the features of a person who is more likely to care for them? They would then switch to a preference for cuteness when they reach maturity. Yet rather than this being the case, babies and young children prefer dolls and soft toys to be as cute as possible. Why is this?

Kate Rosevear, Stockport

Features editor JV Chamary replies: *Parents are programmed to promote the survival of their own offspring (not the species). But you're right: children shouldn't prefer baby-like features, yet they do seem to like cute soft toys. This paradox was studied in 1995, by psychologists at Portsmouth University who were interested in why teddy bears have 'evolved' to be cuter. Examining the preference for baby-faced bears in four-, six- and eight-year-olds, they found that four-year-olds don't, in fact, prefer cuter teddies. So kids don't recognise cuteness at an early age – teddy bear 'evolution' is driven by the preference of adult consumers.*

Not good to be bad

Your article in the May Edition made me wish to respond ('Good to be bad', May, p38). Some people who are good do reach the top: Lord Leverhulme and the Cadbury family are examples. Bad people who reached the top have included Gaddafi and Assad, who now has nowhere to hide. Is it better to be a happy failure or a sad success? When you get what you want, you want something else.

If a computer ever becomes self-aware this could be a problem – as we saw in Hal [in the film *2001: A Space Odyssey*]. Computer programmers will have to make computers see the human race as God – as suggested in Asimov's three laws of robotics.

Laurence Kingsbury

Although I thoroughly enjoyed the article 'Good to be bad', I felt that many questions remain unanswered. For example, to what extent are the effects of 'bad' behaviour due to the novelty of its observation? By this I mean, does the fact that aggressive or narcissistic tendencies are seen as 'wrong' by society draw us to these 'forbidden fruits' in our personalities when they are presented to us?

GREG BRIDGES, R F J ARTHUR

WHAT DO YOU THINK?

post@sciencefocus.com
Focus magazine,
Tower House, Fairfax Street,
Bristol, BS1 3BN

We assume that all views submitted are for publication unless otherwise stated. We reserve the right to edit correspondence for clarity and brevity. We regret we can't reply to all the letters, emails and post we receive.

Also, in the 'Think negative' section I was fascinated by the effects of evil thinking on physical strength, but I wonder whether this would still apply to different religions, backgrounds or time periods. For example, would an orthodox Jew from 1000BC still exhibit the same results, even though they had a belief in an all-powerful force for good?

Finally, and most importantly: what effect could this article have on the morality of Britain?!

Ben Jowett

Speed of light

I read your article in this month's issue on the OPERA tests at CERN, which suggested neutrinos travelling faster than c, the speed of light (April, p77).

I thought that the equations of Special Relativity did not preclude objects travelling faster than the speed of light: just that if anything started in a state where its speed was less than c, it was not possible to accelerate it beyond c? In other words, could the opposite be true: that things faster than c could not be slowed to the point they were less than c? I know it doesn't apply to this experiment; it's just a general query regarding the absolutism of your article.

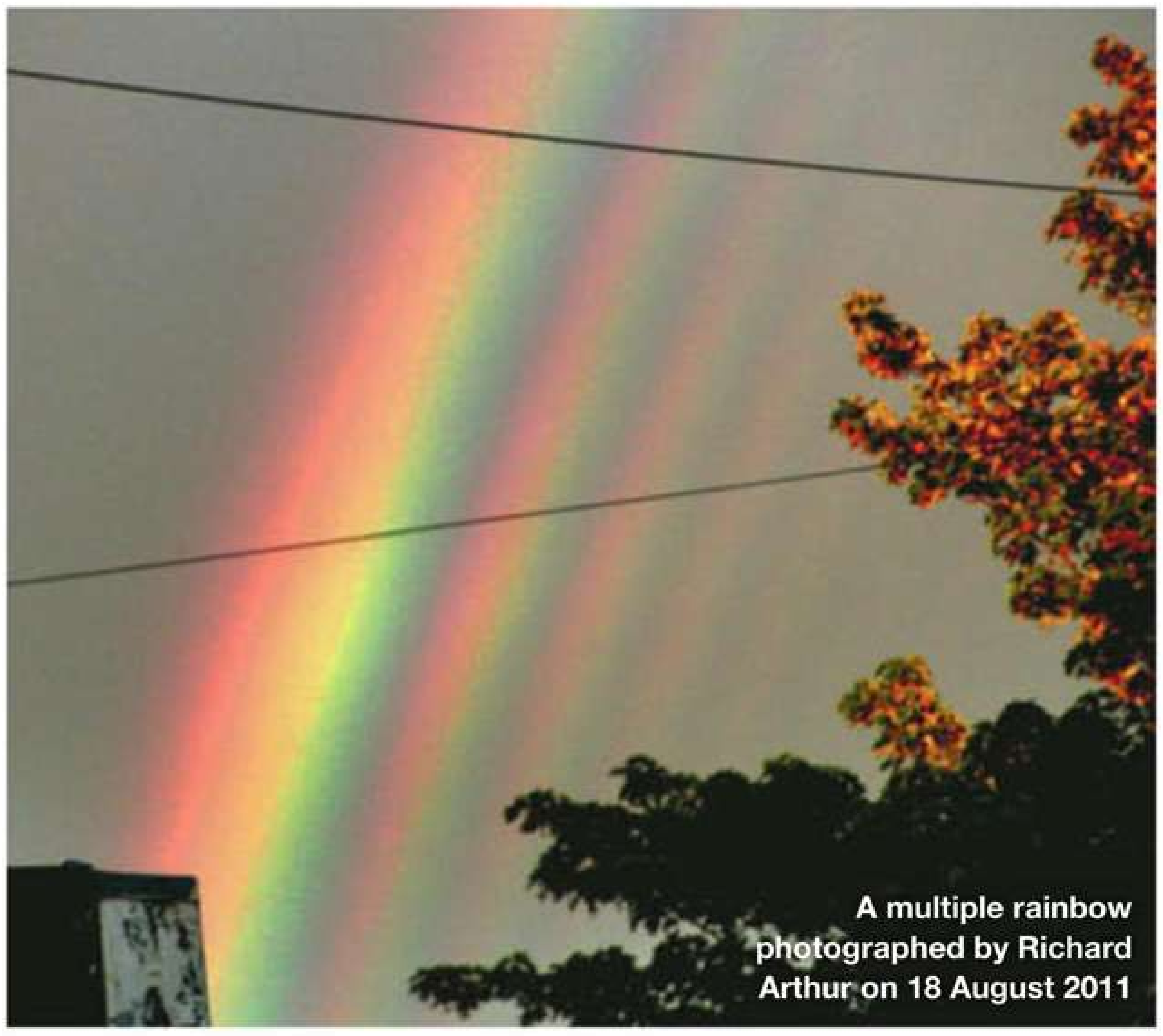
Michel Bendichou

Indeed there are particles (tachyons) that always move faster than light. However, they're only theoretical, and the jury is out on whether they could actually exist without violating the law of cause and effect. ***–Ed***

Careful with that drill...

Given the stickiness and depth of the magma, I believe that we need to find out as much as possible about supervolcanoes ('Should we be drilling into an active volcano? May, p25). So go ahead and drill... but do it cautiously!

Alan Kummer



A multiple rainbow photographed by Richard Arthur on 18 August 2011

Unsinkable ships

Your article 'How to build an unsinkable ship' (May, p66) made for interesting reading, but it doesn't mention airbags, which would inflate to stop a ship from sinking. Why was this?

I have another query: I thought that graphene was only one atom thick. Therefore, even though strong, wouldn't its thinness make it weaker than paper?

Edward Seymour, Brighton

Paul Easthaugh replies: *Although airbags are often used in salvage work to raise wrecks off the seabed, they would need to be many times larger to actually keep a ship afloat, as its weight in air is far greater. With the latest container ships and supertankers being nearly half a kilometre long, the airbags needed would be colossal. They would also need a correspondingly large air storage system to inflate them sufficiently rapidly.*

Graphene is a long way from being a commercially suitable product for use by ship builders, but it might be employed one day. At present, we would need three million layers of graphene to create an incredibly strong sheet 1mm thick.

Over the rainbow

Your response to the triple rainbow question (May, p81) was, I'm sure, accurate. However, the image fell short in that multiple rainbows will always be concentric. Furthermore, the primary rainbow will show red on its outer edge with the secondary showing violet and the tertiary showing red again.

Rob Stewart, Keynsham

I read with interest the article in *Focus* magazine about there only being five reports of three-banded rainbows in the past 250 years. Last summer I saw and photographed a perfect multiple-repeated rainbow. Although some bands were very faint, I could make out seven distinct bands.

Richard Arthur

Oops... In our June issue, we omitted a clue from the crossword on page 107. The clue should have been '14 across: energy source derived from fossilised materials (3).' Competition entries missing this answer are still valid.

IMMEDIATE MEDIA Co

EDITORIAL
Editor **Graham Southorn**
Deputy Editor **Andy Ridgway**
Production Editor **Daniel Down**
Features Editor **JV Chamary**
Reviews Editor **Daniel Bennett**
Science Consultant **Robert Matthews**
Contributing Editor **Emma Bayley**

ART & PICTURES
Art Editor **Sam Freeman**
Designer **Joe Eden**
Picture Editor **James Cutmore**

CONTRIBUTORS
Danny Allison, Stephen Baxter, Susan Blackmore, David Bodycombe, John Brophy, Carolyn Bunt, Oliver Burston, Sarah Castor-Perry, Edward Castronova, Moheb Costandi, Zoe Cormier, Heather Couper, Emma Davies, Russell Deeks, Jane Douglas, Barry Downard, Acute Graphics, Alastair Gunn, Timandra Harkness, Nigel Henbest, Dan Hilliard, Spencer Kelly, Mark Lewney, James Lloyd, M Paul Lloyd, Gareth Mitchell, Michael Mosley, Stephen Noble, Kelly Oakes, Jheni Osman, Mark Pagel, Richard Palmer, Steve Sayers, Penny Sarchet, Chris Sinclair, Bill Thompson, Magic Torch, Luis Villazon, Paul Wootton, Jonathan Wright

ADVERTISING & MARKETING
Advertising Director Caroline Herbert
Advertising Manager Steve Grigg
Senior Brand Sales Exec Iain Bryan
Junior Brand Sales Exec Marc Gonzalez
Classified Sales Exec Rebecca Pye
Newstrade Manager Rob Brock
Head of Subscriptions Marie Davies
Marketing Coordinator Mark Summerton

INSERTS
Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION
Joanna Marshall +44 (0) 20 433 2183

PUBLICITY
Press Officer Carolyn Wray

PRODUCTION
Production Director Sarah Powell
Production Coordinator Pip Smith
Ads services manager Mel Watkins
Ad coordinator Natasha Murray
Ad designer Laura Phillips

PUBLISHING
Publisher Andrew Davies
Chairman Stephen Alexander
Chief Executive Officer Tom Bureau
Deputy Chairman Peter Phippen
Managing Director Andy Marshall

BBC WORLDWIDE MAGAZINES UNIT
Managing Director Nicholas Brett
Publishing Director James Hewes
Editorial Director Jenny Potter
Unit Coordinator Eva Abramik

EDITORIAL BOARD
Deborah Cohen, Jane Fletcher, John Lynch, Bill Lyons, Gareth Mitchell, Ayesha Mohideen

abc Audit Bureau of Circulations
67,727 (Jul-Dec 2011)

Annual subscription rates (inc P&P): UK/BFPO £49.40; Europe & Eire Airmail £54.96; Rest of World Airmail £59.99.

Focus provides trusted, independent advice and information that has been gathered without fear or favour. When receiving assistance or sample products from suppliers, we ensure our editorial integrity and independence are not compromised by never offering anything in return, such as positive coverage, and by including a brief credit where appropriate.

FOLLOW FOCUS
facebook
facebook.com/sciencefocus
twitter
twitter.com/sciencefocus

© Immediate Media Co Bristol Ltd 2012. All rights reserved. Printed by William Gibbons Ltd.

Immediate Media Co Bristol Ltd accepts no responsibility in respect of products or services obtained through advertisements carried in this magazine.

FOCUS SUBSCRIPTION ORDER FORM

FOP243

☐ **Yes, I would like to subscribe/renew my subscription to *Focus* and receive my first 5 issues for just £5***

(please complete the form below)*

Instructions to your bank/building society

DIRECT Debit

To: The Manager (Bank/Building Society)

Address

Postcode

Name(s) of account holder(s)

Bank/building society account number

Branch sort code

Reference number (internal use only)

Originator's identification number: 7 1 0 6 4 4

Please pay Immediate Media Co Bristol Ltd Debits from the account detailed in this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with Immediate Media Co Bristol Ltd and, if so, details will be passed electronically to my Bank / Building Society.

Signature

Date

Banks and building societies may not accept Direct Debit mandates from some types of account

Your details (ESSENTIAL)

Title **First name**

Surname

Address

Postcode

Home tel number

Mobile tel number**

Buying a print subscription to *Focus* entitles you to access and download digital issues of *Focus* through the *Focus* iPad app, available from the App Store free of charge. Simply enter an email address below and we'll send you full details of how to set up your account.

Email address**

Immediate Media Company Limited (publisher of *Focus*) would love to keep you informed by post or telephone of special offers and promotions from the Immediate Media Company Group. Please tick if you'd prefer not to receive these .

**Please enter this information so that *Focus* may keep you informed of newsletters, special offers and other promotions by email or text message. You may unsubscribe from these at any time. Please tick here if you'd like to receive details of special offers from BBC Worldwide via email .

Other payments For a year's subscription (13 issues)

UK – 13 issues by credit/debit card or cheque for just £35.90 **SAVE 30%**

Europe – 13 issues by credit/debit card or cheque for just £54.96

ROW – 13 issues by credit/debit card or cheque for just £59.99

I enclose a cheque made payable to Immediate Media Co Bristol Ltd for £__________

CREDIT CARD

Visa Mastercard Maestro

Card no.

Issue no. (Maestro only) Valid from Expiry date

Signature **Date**

***Offer ends 27 JUNE 2012** Trial offer only available to UK residents paying by Direct Debit. After your trial period your subscription will continue at just £16.59 every 6 issues, saving 30% on the shop price. If you cancel within 2 weeks of receiving your fourth issue you will pay no more than £5. Your subscription will start with the next available issue.

POST ORDER FORM TO:
***FOCUS*, FREEPOST LON16059,**
Sittingbourne, Kent, ME9 8DF

Every month BBC *Focus* magazine brings you...

» FEATURES Covering the latest developments in science and technology

Q&A
Your questions answered
What is the chance of an asteroid hitting Earth?
£121 billion
Is dark matter distributed evenly throughout the Universe?

» Q&A Your questions about the world around you answered by our experts

» THE GUIDE All the latest cutting-edge gadgets tried and tested in the *Focus* labs

SUBSCRIBE TODAY

SPECIAL SUBSCRIPTION OFFER

Try 5 issues for just £5*

when you subscribe to FOCUS today

BBC SCIENCE • TECHNOLOGY • FUTURE
FOCUS
Q&A How does a knife cut? PLUS 27 more of your science questions answered
THE AMAZING SCIENCE OF DOGS
How to build a starship
FOOTBALL'S TECH FUTURE
SPECIAL REPORT
THE Origin OF Life
New clues to where it started and how it evolved
Action cam
Stephe Baxt
Windows 8 preview
Spy tech
June 2012 HIGHLIGHTS
Football's tech future
Action cams

Plus get FREE access to the Focus app!

Your special subscription offer includes...

- Your first **5 issues for just £5***
- After your trial period, continue to save. Pay **just £16.59 every 6 issues by Direct Debit – saving you 30%!**
- Get every issue **delivered direct to your door**
- Get **FREE access to iPad editions of *Focus*!** Tell us your email address when you subscribe and we'll send you full details of how to register your account
- Hurry – this exclusive **offer ends 27 June 2012**

Subscribe online
www.buysubscriptions.com/focus

Or **call now** on
0844 844 0260†

Please quote FOP243

†Calls to this number from a BT landline will cost no more than 5p per minute. Calls from mobiles and other providers may vary. Lines are open 8am-8pm weekdays & 9am-1pm Saturday.

ISTOCKPHOTO.COM/BLIXEN, ILLUSTRATION BY SPOOKY POOKA

HOW TO BUILD A BRAIN

It's the body's most complex organ – the tangle of cells that makes us who we are. But, says **Moheb Costandi**, scientists think they can now create an artificial human brain

Alan Mathison Turing was one of the leading scientific minds of his time. He cracked German codes in World War II and is widely regarded as the father of the modern computer. But he wasn't simply driven by the challenge of solving problems. It was the sudden death of his close friend Christopher Morcom, when Turing was just 17, that profoundly shifted his view of the world. It underpinned many of his greatest discoveries and led him towards his biggest challenge – to build a human brain.

The death of Morcom in 1930, an intellectual companion for Turing, led him to consider how the human brain worked. He came to the conclusion that it was simply a machine with a series of logic gates – on/off switches – that underpin all our thought processes. As such, he believed there was nothing that couldn't be replicated in a man-made machine. In other words, we could build an artificial brain.

Turing died before he achieved this goal. But now, 100 years after his birth, some scientists are daring to think they might be able to recreate the body's most complex organ. Their plan isn't to build a brain out of the 86 billion nerve cells, or neurones, that make up our brains. Instead, they plan to recreate a brain in digital form – using software, silicon and wires.

One of the most ambitious of these initiatives is the Human Brain Project, led by Professor Henry Markram of École Polytechnique Fédérale de Lausanne in Switzerland. His plan is to integrate everything that is known about the brain, from the molecular level up through to its large-scale anatomical structure (see 'Building blocks of the brain', on p34), in one working model that resides in a supercomputer. It's a huge challenge requiring big money. In March, Markram's proposal was selected as one of six finalists in a European Commission competition for €1 billion (£0.8 billion).

To build the artificial brain, models of all the processes that go on inside the real thing would need to be encoded in software and brought together so they can interact. The hope is that the resulting 'unified model' would provide insights into what makes us tick – exactly how our thoughts and behaviour come about.

"We know a lot about the brain and we have very good knowledge about its components," says the brain project's spokesman Richard Walker, "but our systematic knowledge of how they work together is weak.

"We can put information about the behaviour of individual cars into a computer and generate a simulation that will predict traffic jams. In the same way, simulating how the components of the brain behave ▶

and interact could give us an overall picture of how they all work together. What the brain actually does in life will emerge from the interactions of these lower-level parts."

Mind-boggling complexity

It's not going to be an easy task. The brain's 86 billion neurones form something like one quadrillion synapses (that's one thousand billion), which are being modified continuously, countless times every second. Simulating this complexity would involve processing a huge data set, the size of which approaches that of all the stored information in the world. This would require at least an exaflop of computing power, executing roughly a trillion operations per second. Even today's most powerful supercomputers aren't up to this gargantuan task.

But Markram has a good track record in the field. In 2008, he and his colleagues used IBM's Blue Gene supercomputer to simulate a tube-shaped column of neurones in a rat brain, a column containing 10,000 nerve cells with 30 million connections, or synapses, between them. Now, they have simulated 100 such columns.

Markram's team will generate the human brain simulation using some of their own data. Earlier this year, for example, they published details about the combination of ion channels expressed in several types of neurones in the rat brain. Data from outside sources, such as the Human Connectome Project in which the major pathways of neurones in the brain are being plotted, will be built into the simulation too.

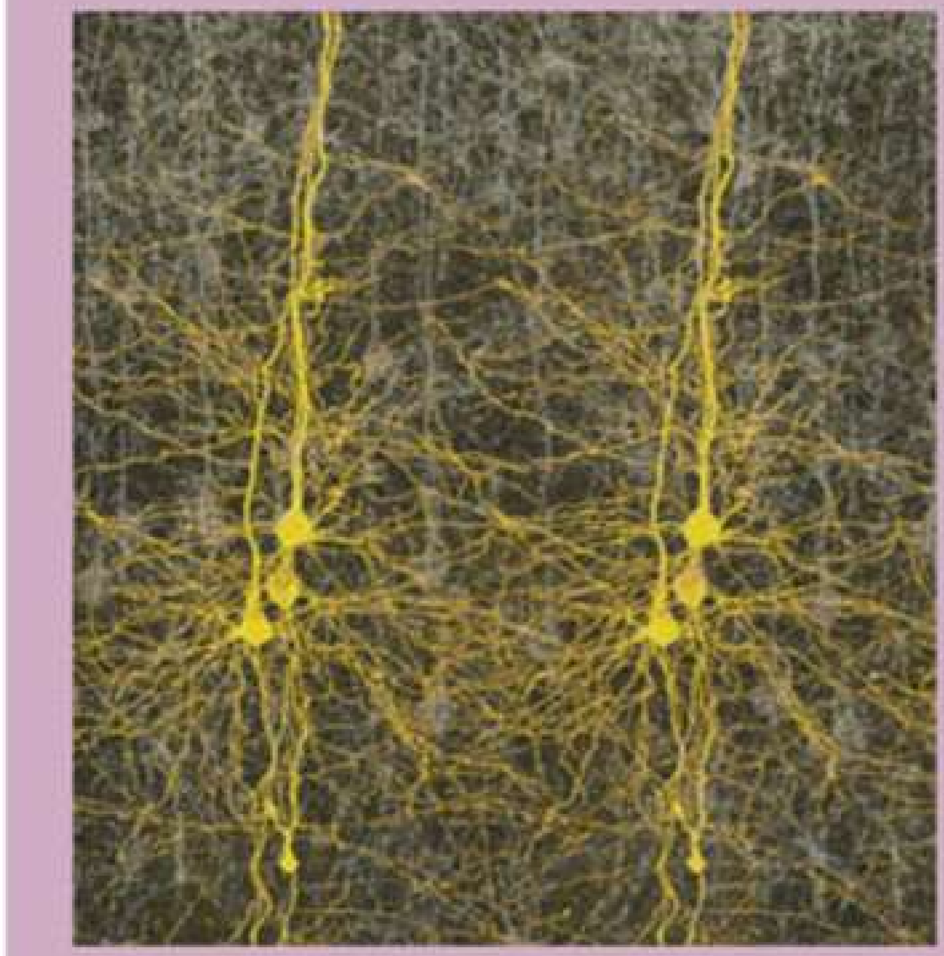
As well as providing new insights into the workings of the brain, Walker believes the resulting simulation could lead to new treatments for diseases. "If we know that schizophrenia is due to some molecular defect, we can simulate that in the model and then do experiments that are otherwise impossible to do in the lab," he says.

And the benefits would not be limited to medicine. "The human brain is amazing. Every day, it absorbs the same amount of energy as a light bulb. It learns by itself without being programmed and can run for more than 70 years without serious defects," says Walker. "If we could

> "Simulating the brain would involve processing a data set the size of all the stored information in the world"

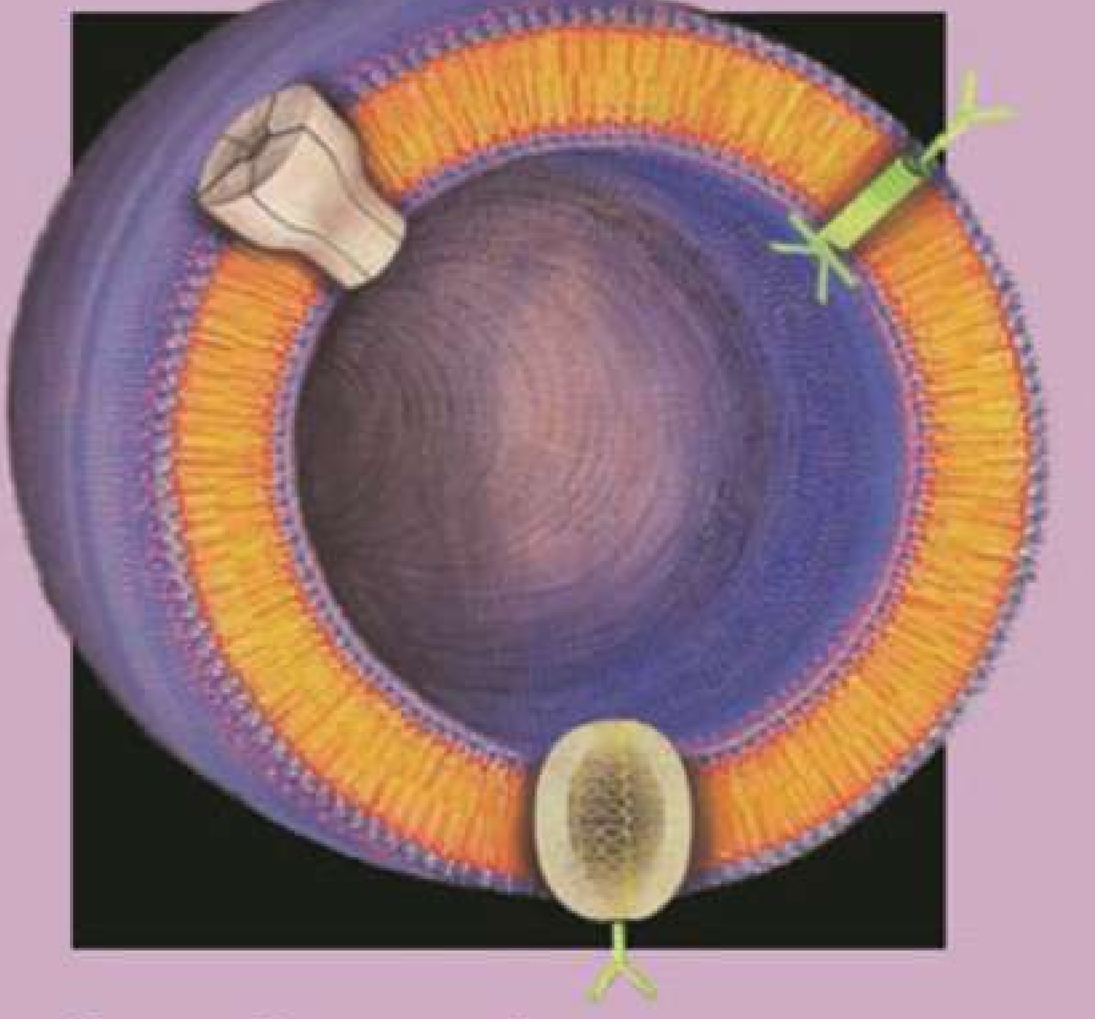
BUILDING BLOCKS OF THE BRAIN

The key components that would need to be incorporated into an artificial brain



Cortical columns

These are vertical structures in the cerebral cortex, the outer layer of the brain. It plays a key role in memory, thought and language. The columns contain groups of neurones specialised to perform a particular function. There are about half a million of them, each containing about 60,000 neurones.



Ion channels

These pores span the nerve cell membrane and control the electrical activity of neurones, turning them on or off. As such, their behaviour is crucial to how the brain behaves. They exert their control by allowing electrically-charged atoms (or ions) of calcium, sodium and potassium to enter or leave the cell.

ADVANCES IN NEUROSCIENCE

Key steps towards building an artificial brain

1852

German physician Hermann von Helmholtz measures the speed of nerve impulses. The conventional wisdom at the time was that impulses are propagated instantaneously. Helmholtz used an induction coil to send electrical surges through the nerves of frogs, showing that they conduct electricity at a speed slow enough to be measured.

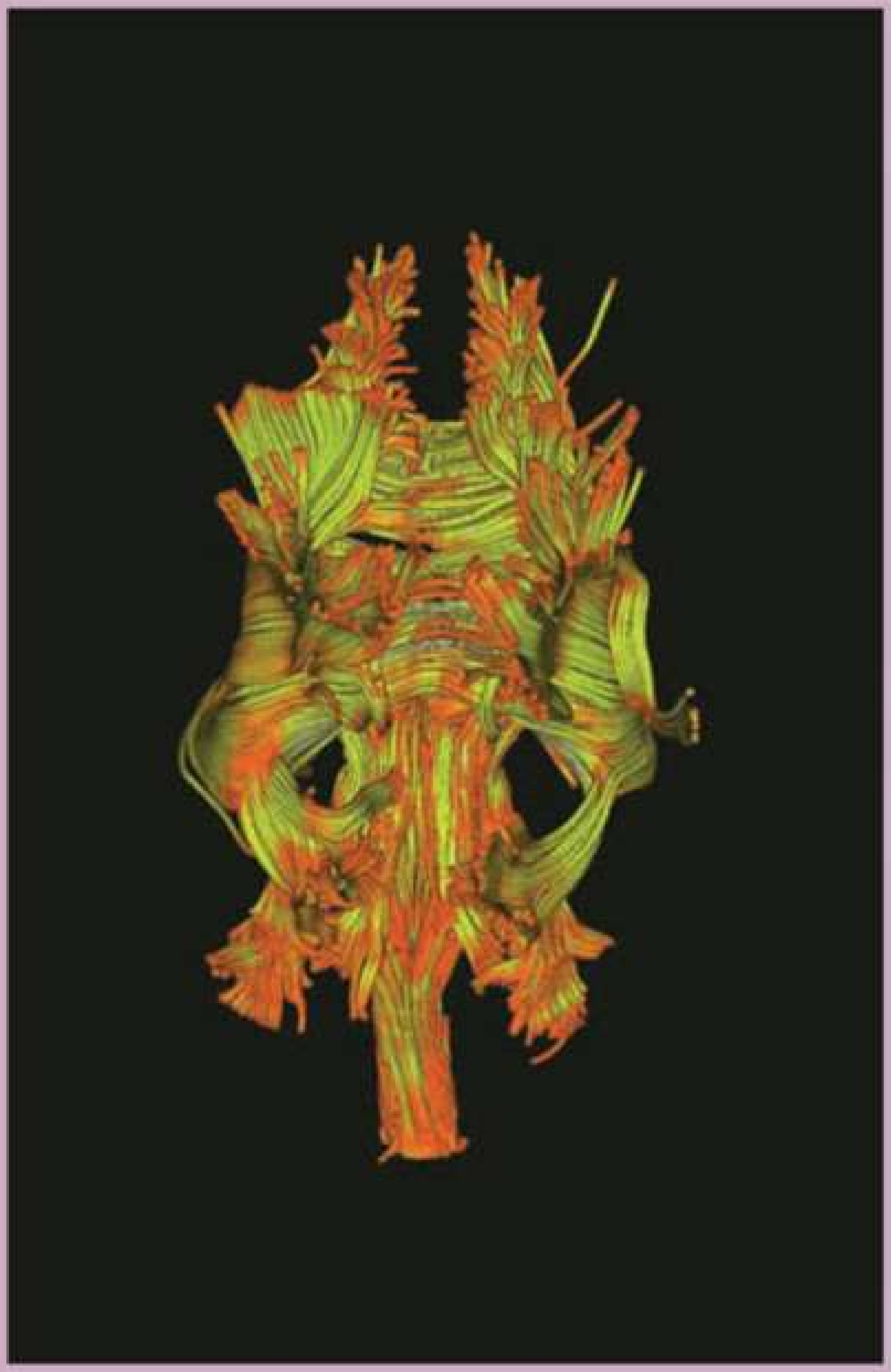
1897

English physiologist Charles Sherrington coins the term 'synapse' to describe the junctions between neurones following experiments on spinal reflexes in which he noticed a short delay in the transmission of impulses. It was not until the 1950s, when powerful electron microscopes were invented, that synapses were observed directly.

BLUE BRAIN PROJECT, SCIENCE PHOTO LIBRARY X3, THINKSTOCK X3, UNIVERSITY OF MANCHESTER, CORBIS X2

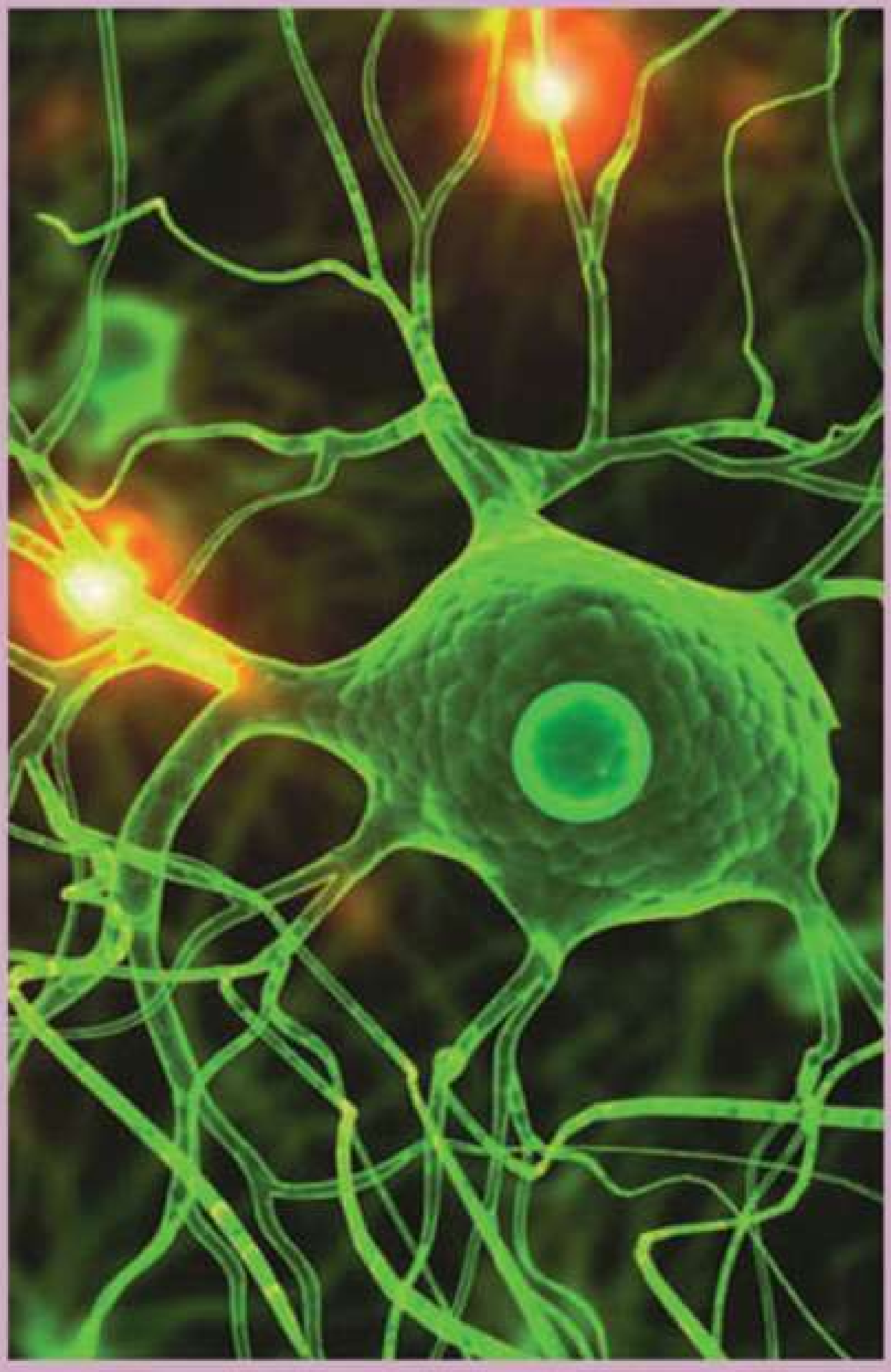
Synapses

The junctions between neurones where communication between different nerve cells takes place, either electrically or chemically. Each neurone can have many synapses, with the result that the human brain contains something like one quadrillion junctions. Learning and memory are widely believed to involve the strengthening of synapses in distributed networks of neurones.



White matter tracts

These are large bundles of nerve fibres, or axons, that form long-range connections between different parts of the brain. The fibres are insulated by a fatty tissue, myelin, which increases the velocity at which nervous impulses travel and gives the tissue its white appearance. Recent research shows that the brain's white matter tracts are arranged in a highly ordered three-dimensional grid.



Neurones and glia

These are the two main cell types within the brain. It is the interconnected networks of neurones that encode and process information and about 86 billion of them would be needed to be included in an artificial human brain. Glial cells have been thought of as nothing more than support cells, but we now know that certain types make important contributions to information processing.

imitate the brain to build machines with some of these capabilities, we could revolutionise information and communications technology."

If Markram and his colleagues hear they have been awarded the money later this year, they will bring together scientists from more than 100 international research centres working in neuroscience, robotics, genetics, and mathematics. If they don't get the money, they say they will continue with the work regardless, albeit at a slower pace.

Many researchers have criticised the project, arguing that it is ill-conceived and over-ambitious. One of the most outspoken critics is neuroscientist Professor Rodney Douglas of the Institute of Neuroinformatics in Zürich. "A description of the brain is not an explanation of how it works," he says. "It doesn't follow that a better understanding of the brain will necessarily emerge from encoding its detailed organisation in a computer. The claim that a theory of brain function would emerge from a simulation is very extravagant."

A different approach is being taken by Dr Dharmendra Modha who works for IBM in the US and runs the global

▶

1906

Using a new dye, Spanish neuroscientist Santiago Ramón y Cajal determines that neurones are the brain's functional units. In the 19th century an ongoing debate had some scientists arguing that the brain consisted of distinct cells, others that it was a network of tissues. Cajal settled the argument.

1921

Pharmacologist Otto Loewi discovers the first known neurotransmitter. He took two frog hearts, one with its vagus nerve attached. When this was slowed with an electrical current, the second slowed too. Loewi surmised that a chemical, we now know to be acetylcholine, was released by the first heart and affected the other.

1944

Alan Turing tells a colleague Donald Bayley of his desire to build a brain. The impetus is the death of his friend Christopher Morcom in 1930. It is an event that leads him to consider the mind and its relationship to the brain. Turing is convinced a machine can be created that can mimic anything the brain can do.

▶ SyNAPSE project. Instead of building a brain using software, his team plans to build its components using hardware – reproducing the organ's structures in silicon. And where Markram and his team's primary aim is to understand how the brain works, Modha is more interested in mimicking the brain to build truly intelligent machines that can program themselves and learn from experience.

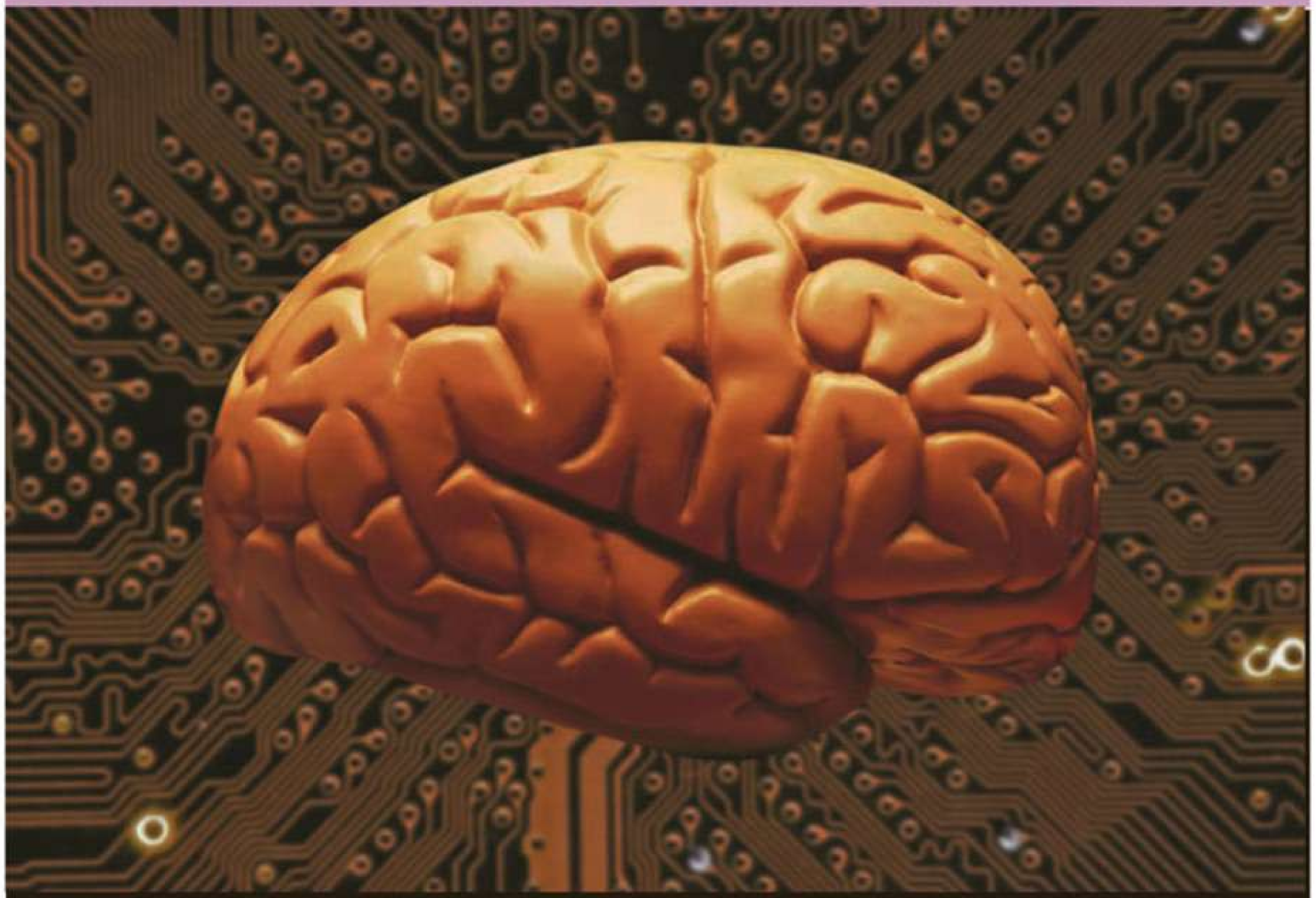
Hard-wired brain

Modha's approach, known as neuromorphic computing, was pioneered by Professor Carver Mead of the California Institute of Technology. Working with PhD student Misha Mahowald, he developed the first neuromorphic device in the late 1980s – a silicon retina in which electrical circuits mimic the function of the eye's rod and cone cells.

Neuromorphic computing promises to provide supercomputing performance at an affordable price by overcoming the constraints of conventional computers. Developed in the 1940s by early computer scientist John Von Neumann and others, conventional computer architecture separates the central processing unit from the memory, so that information has to be shuttled back and forth between the two through another component called a bus. Packets of information are processed one at a time and sent to the memory individually. This creates

CAN WE REALLY BUILD AN ARTIFICIAL HUMAN BRAIN?

The prospect of reconstructing the most complex organ divides opinion



YES

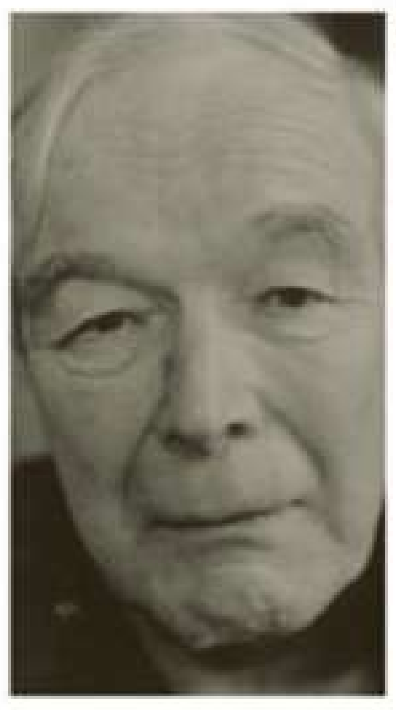
Professor Henry Markram
Leader of the Human Brain Project

"Supercomputers are becoming powerful enough to simulate the brain with biological detail and accuracy. They can help us construct a multi-level view of the brain showing how all its parts work together. The volume of data on the healthy and diseased brain is increasing exponentially: big science initiatives are screening the brain at various levels and theoretical neuroscience, mathematics and statistics have reached a point where they can begin to analyse it all. But understanding the brain is not a one-man show. It will require many disciplines coming together, with hundreds of Einsteins sitting around a table to solve the problems systematically."

NO

Professor Rodney Douglas
Neuroscientist at the Institute of Neuroinformatics, Zürich

"Claims that we can learn something new from a simulation miss an important principle. That is that simulation involves understanding a functional system from observed data, then creating an abstract model before converting it into a code that is optimised for computer hardware. Your computer then runs this simulation, but not the physical processes themselves. You'll only retrieve the consequences of what you have input from the simulation; not the behaviour of the original system. In other words, it never rains inside a weather simulation because the physics of computation has nothing to do with the physics of weather."



1952

British physiologists Alan Hodgkin and Andrew Huxley set out to discover what happens when a neurone is stimulated. By impaling giant nerve fibres, or axons, from squid with fine wires called microelectrodes, they determine that impulses are generated by the flow of ions, or charged atoms, across the nerve cell membrane.

1959

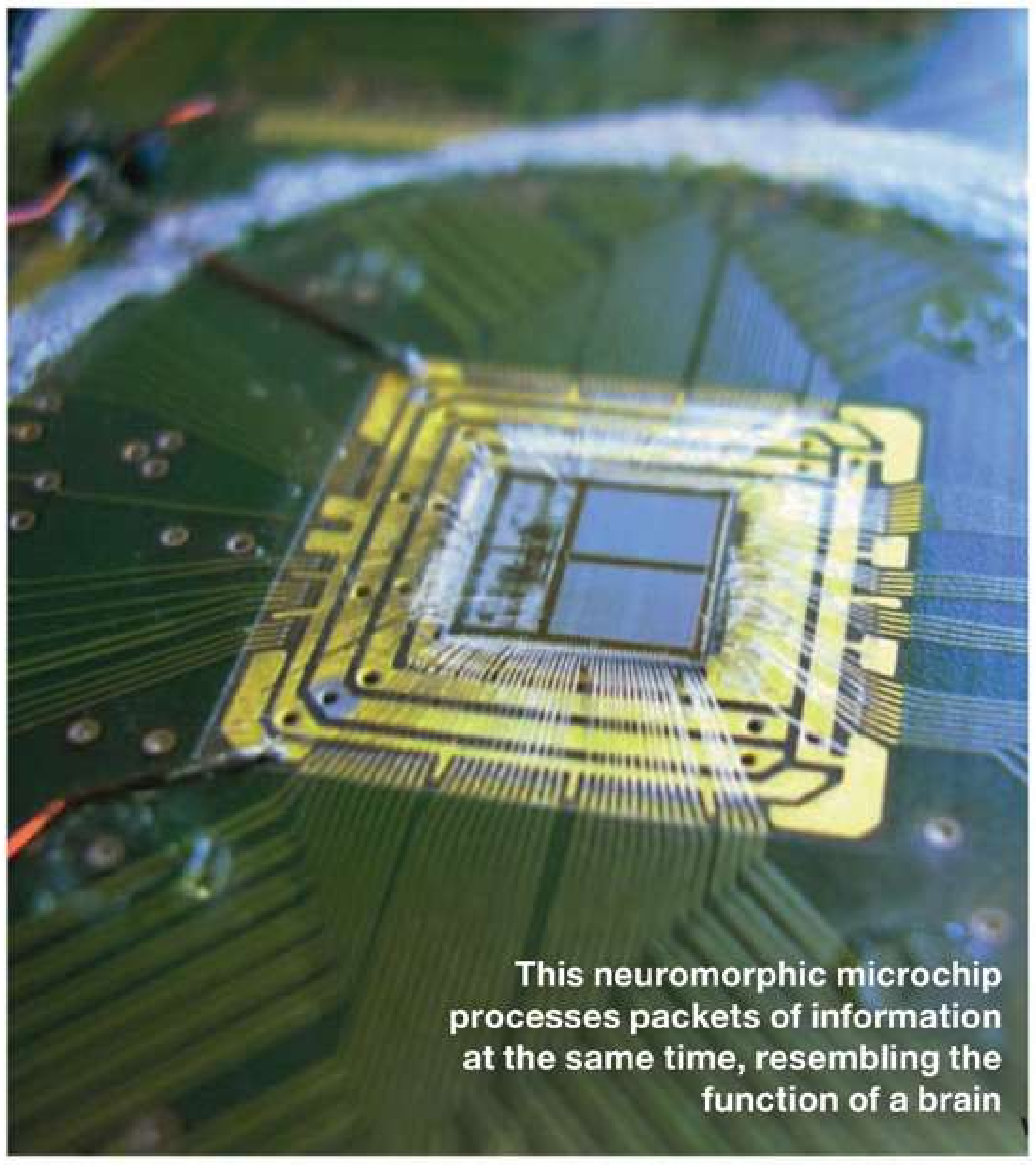
Neurobiologists David Hubel and Torsten Wiesel publish a research paper describing the visual system of cats. They found that individual neurones in the primary visual cortex are sensitive to movement in specific directions. The pair go on to show that the visual cortex is organised in alternating columns devoted to the left and right eye.

1988

US computer scientist Carver Mead develops the concept of neuromorphic computing by describing very-large-scale integrated (VLSI) systems mimicking the architecture of the brain. He subsequently works with PhD student Misha Mahowald to develop the first neuromorphic microchip, a silicon replica of three cell layers in the retina.

GETTY X2, SYNAPSE PROJECT, BLUE BRAIN PROJECT X2, HANNES ROST, SCIENCE PHOTO LIBRARY X2, THINKSTOCK

Dr Dharmendra Modha is trying to build a brain in silicon with the SyNAPSE project



This neuromorphic microchip processes packets of information at the same time, resembling the function of a brain

a processing bottleneck that uses lots of energy, slowing the computer.

Crucially, neuromorphic chips integrate the computational units and the memory components on the same silicon circuit and process multiple pieces of information in parallel, more closely resembling the brain – increasing processing speed and reducing the energy required. "Von Neumann architectures are very good at calculations and repetitive tasks, but the brain is fundamentally different," says Ton Engbersen, a senior researcher at IBM's Zurich lab who is involved with the SyNAPSE project. "It's very good at interpreting what we see and all other kinds of what we call 'unstructured data'."

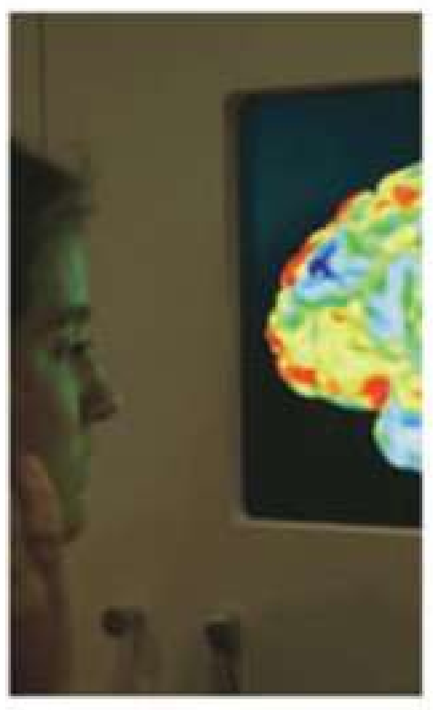
Last year, Modha's global team of scientists unveiled the most sophisticated neuromorphic chip yet: a 'neurosynaptic core' consisting of 256 neurones and more than 260,000 synapses replicated in silicon. The 'weight', or strength, of each synapse can be pre-programmed into the simulation before it is run, enabling the chip to perform navigation and pattern-recognition tasks.

"I believe there's an algorithm for how the brain learns, although we don't know that yet," says Engbersen. "We are trying to build the next generation of computers that can process information and learn in the same way as the brain." In the long run, the IBM team is planning to develop a human-scale system containing one quadrillion synapses distributed across multiple neurosynaptic core chips.

But while most neuroscientists agree that the mind is an emergent property of the brain, it's not clear whether something like human intelligence would emerge from one of these artificial brains. ▶

> *"I believe there's an algorithm for how the brain learns, although we don't know that yet"*

1990

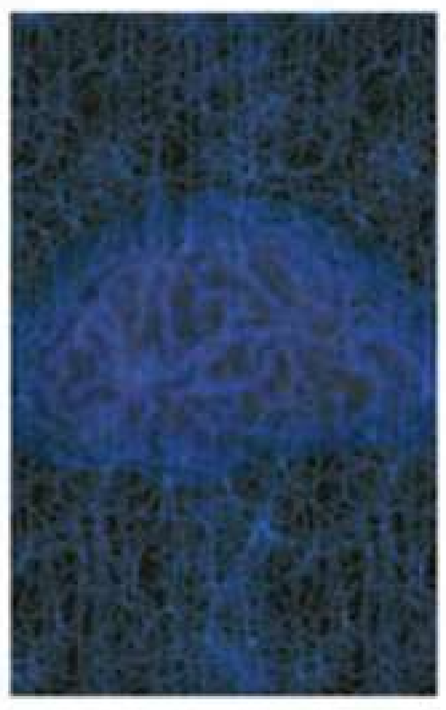


Japanese researcher Seiji Ogawa and colleagues develop functional magnetic resonance imaging (fMRI), a technique that measures activity in the brain by detecting blood flow. fMRI is now widely used and provides information about how connected networks in the brain participate.

1998

Rod MacKinnon, a neurobiologist in the US, describes the three-dimensional structure of an ion channel in a neurone for the first time. MacKinnon and his colleagues isolate the potassium channel from bacteria and discover what it looks like using a technique called X-ray crystallography.

2012



Neuroscientist Henry Markram proposes the Human Brain Project, which aims to collate all existing knowledge about the brain, including data from the Allen Brain Institute's gene expression atlas. The aim is to use the data to generate a supercomputer simulation of the human brain.

Henry Markram gives a TED talk on his work with the human brain

▶ Dr Kwabena Boahen, principal investigator at Stanford University's Brains in Silicon research group, believes it would. "How else could intelligence emerge? It has to come out of stuff we can build. The physics of how neurones work is very similar to the physics of transistors. As we learn more about the brain, we can replicate its functions." Turing would have undoubtedly agreed.

Boahen and his colleagues have built a neuromorphic supercomputer that rivals the performance of IBM's Blue Gene while consuming 100,000 times less energy. They are using it to run a real-time simulation of a million neurones interconnected with something in the order of a billion synapses. The aim is to understand how the brain decides where to focus attention and how we choose what to do – how cognition happens through the actions of neurones.

"The brain is not made out of some alien technology," says Boahen, "and there's nothing going on in there that we can't replicate in silicon. We know a lot about how individual neurones and synapses work. It's a matter of figuring out how complex phenomena emerge when lots of them are hooked up to each other."

Melanie Mitchell, Professor of Computer Science at Portland State University in the US, agrees that the brain could eventually be replicated, but argues that our knowledge of how it functions is woefully inadequate. "In principle, we can replicate anything the brain does," she says. "But in practice it's going to be very difficult. We don't yet know enough about the brain to say what its core algorithms are."

Markram's team used the Blue Gene supercomputer to simulate part of a rat's brain

> *"There's nothing going on in the brain that we can't replicate in silicon"*

Fathoming the brain

New research is revealing just how little we understand about our most complex organ. After British physiologists Alan Hodgkin and Andrew Huxley discovered that nervous impulses are generated by the flow of ions, or charged atoms, in 1952, we came to view neurones as computational units that function as binary switches, existing in either an 'on' or 'off' state. In recent years, however, neuroscientists have come to realise that neurones are more complex. Rather than being binary switches, they exist in many different states. And the nervous impulses that travel along them can move in both directions, not just one.

No-one – not even Markram and Modha – believe that building an artificial brain is going to be easy. To a large degree, the human brain is a black box filled with many smaller black boxes: after a century of investigation, the workings of some of these boxes remains a mystery. But while the prospects of completely achieving Turing's ultimate aim still seem slim, just like Turing, the lessons we can learn as we strive to achieve this goal could be revolutionary. ■

Moheb Costandi is a molecular and developmental neurobiologist turned science writer

FIND OUT MORE

http://bit.ly/henrymarkram
TED talk by Henry Markram on simulating a brain

http://bit.ly/kwabenaboahen
TED talk by Kwabena Boahen on building a brain

TED/JAMES DUNCAN DAVIDSON, BLUE BRAIN PROJECT

snapdragon™
by Qualcomm

The digital brains inside the smartest mobile devices.

Snapdragon™ processors let you do more, even faster. And with their single-chip technology inside you'll enjoy better battery life too. Snapdragon processors also take mobile gaming to another level by delivering console-quality, high-res 3D graphics and effects. No wonder they are now found inside over 340 mobile devices.

Learn more at qualcomm.co.uk/snapdragon or experience its processing speed at

Carphone Warehouse

Qualcomm and Snapdragon are trademarks of Qualcomm Incorporated, registered in the United States and other countries. The Snapdragon logo is a trademark of Qualcomm Incorporated.

The mind of Alan Turing

This June marks 100 years since the birth of the computing pioneer – his genius touched many fields…

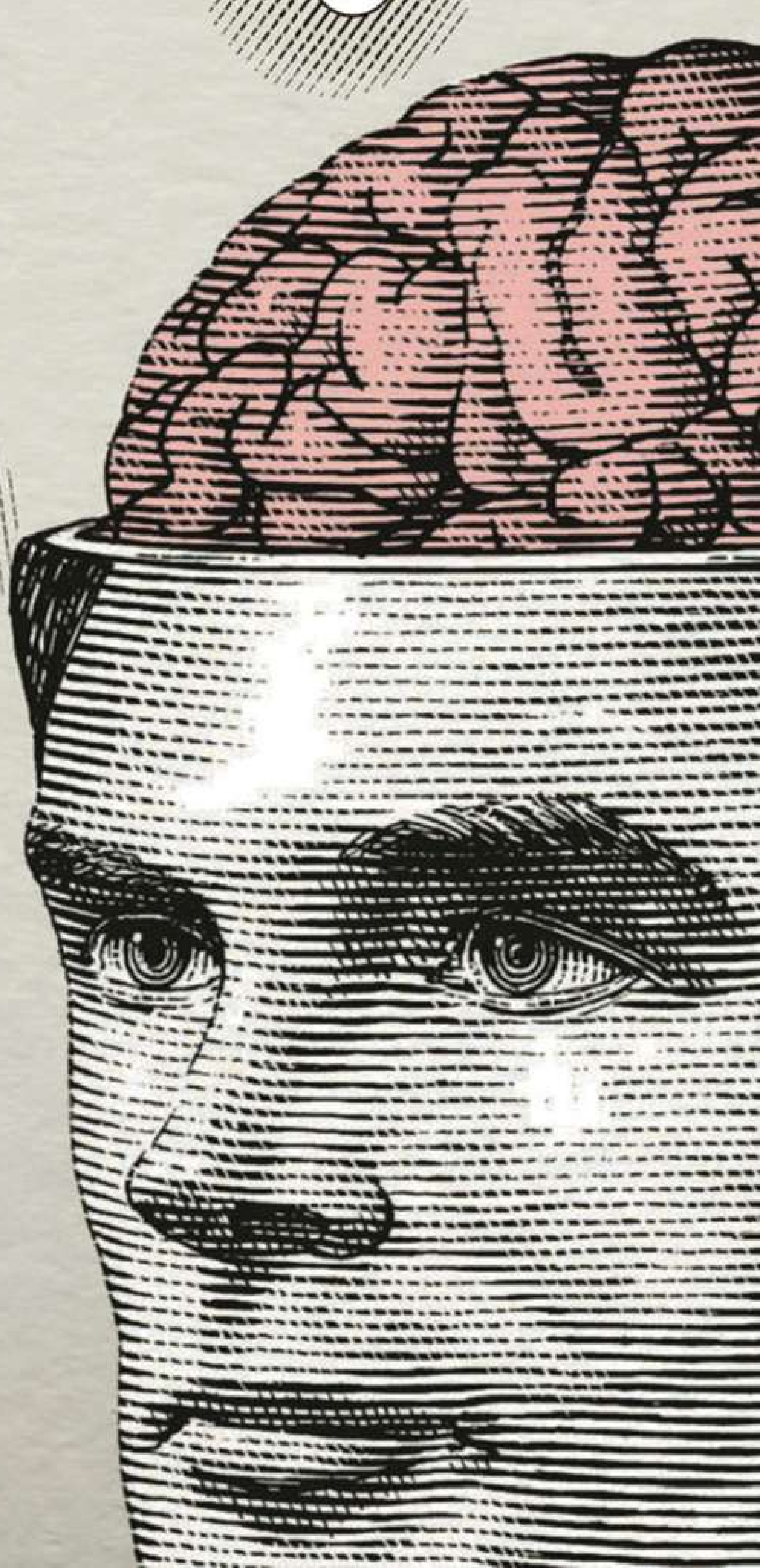
ILLUSTRATION: STEVEN NOBLE

CODE BREAKER

At the UK's secret decryption centre at Bletchley Park in World War II, Turing became the top scientific expert, breaking enciphered German military messages. In 1939 he devised the critical logic for a machine, the Bombe (pictured), developed to break messages encoded by the German Enigma machine. He later took charge of a special section deciphering naval messages, with a direct impact on the war in the Atlantic: his work allowed messages sent to German U-boats to be decrypted.

PROBLEM SOLVER

Turing dreamt up the idea of a universal problem-solving machine, but he knew such a machine need not remain confined to mathematical problems. Much of his life was devoted to understanding the power of these 'universal machines', which are now called computers. Ultimately, the reason there's always 'an app for that' lies in the power of Turing's vision. He was keen to build problem-solving machines and while at Princeton University in 1937, he constructed a cipher machine for making coded messages, a useful skill when it came to cracking the German Enigma machine (pictured).



BIG THINKER

In 1935, aged just 23 and having graduated in maths from Cambridge, Turing tackled one of the deepest problems in mathematics: is there a universal recipe that is guaranteed to produce a solution for any problem? Turing ingeniously captured the vague ideas of a 'recipe' and 'solution' via an imaginary machine that can perform any mathematical process and stops when it reaches an answer. Turing showed that although such a machine can be fed any problem, it isn't always possible to tell if the machine will ever stop. In other words, he'd proved that some problems in maths are unsolvable.

SCIENCE AND SOCIETY PICTURE LIBRARY X2, PRESS ASSOCIATION, GETTY X2, THINKSTOCK, ILLUSTRATION BY STEVEN NOBLE

COMPUTER DESIGNER

Turing is best known for breaking codes, but he also worked on keeping communications secure, devising a speech encipherment system in World War Two. To make it work, he needed the speed of electronics. His design included electronic valves, which acted as switches, giving him the ability to store bits of information and build up logic circuits. By 1945 he had put all this into a detailed design for a real-life universal machine: an electronic computer (pictured). A version of it was built by the National Physical Laboratory in London in 1950 and is now in the Science Museum.

SOFTWARE PIONEER

Turing's ideas in 1946 about what we now know as software were prescient. "Every known process" would be turned into programs for this new universal machine, the computer. His examples were for science, office data processing and code breaking. They showed that computers naturally worked with symbols of any kind, not necessarily numbers, something today reflected in their use for everything from music to text messages. Turing's Abbreviated Code Instructions, written in 1947, mark the beginning of programming languages.

FATHER OF ARTIFICIAL INTELLIGENCE

Turing worked on computing methods that imitate the brain, with networks of artificial brain cells, or neurones, enabling the computer to learn from experience. His 1950 paper *Computing Machinery And Intelligence* includes what's now called the Turing Test (pictured) of artificial intelligence: if questions are put to a computer and it's hard to tell if the responses are from a computer or a human, the computer should be considered intelligent. Turing predicted that by 2000 computers would be able to pass the test; we're still waiting.

ANALYST OF NATURE

In 1950, Turing used one of the first computers for his personal research in biology. He developed a theory of how the shapes of plants and animals can emerge from a chemical soup. Stripes and spots and the appearance of mathematical patterns in the heads of sunflowers were among the examples he studied. Turing's research on the origin of biological form – morphogenesis – was cut short by his untimely death in 1954. Today, it is at the cutting edge of biology, with researchers testing his theories in real biochemical systems.

NASA/KSC

FLIGHT OF THE DRAGON

SpaceX's craft heralds a new era of spaceflight. **James Lloyd** looks at the company's efforts to commercialise the final frontier

This was the scene in late April 2012, as the Dragon spacecraft waited in a hangar in Cape Canaveral, Florida, for its chance to make history. As you're reading this, the spacecraft before you – the SpaceX Dragon capsule – could be in orbit with the International Space Station (ISS).

If all went according to plan, the craft was scheduled to lift off atop a Falcon 9 rocket on 19 May, splashing down in the Pacific Ocean off the coast of California roughly 21 days later. In doing so it will become the first commercial vehicle to dock with the ISS. Reaching this point is a remarkable feat given that the company that built both Dragon and Falcon, Space Exploration Technologies, or SpaceX, was only founded a decade ago. But then it does have Elon Musk, the billionaire entrepreneur co-founder of internet company PayPal, at its helm.

Dragon has largely been built in clean rooms at SpaceX's manufacturing facility in Hawthorne, California, with some of the final assembly taking place in a hangar near the Cape Canaveral launch site. In recent months, much of the final preparation has revolved around software. "We've done all kinds of tests: ▸

The Dragon capsule is positioned against the second stage of the Falcon 9 rocket in SpaceX's hangar in Cape Canaveral. Dragon's nose cone, which jettisons after launch, is missing from the tip of the craft.

▸ systems tests, software tests, and what are called software- and hardware-in-the-loop tests, where you run the software with the hardware," says SpaceX's Kirstin Grantham.

On its first test mission to the ISS, Dragon's payload was set to be non-critical supplies of food and equipment. But if everything goes to plan, there will be 12 resupply flights to the space station, earning SpaceX $1.6 billion. Another company, Orbital Sciences, also has a contract to keep the ISS supplied, but its plans are not as advanced. The first test flight of its rocket and cargo-carrying craft is not scheduled to take place until October.

In the longer term, Dragon could ferry astronauts to the ISS, a key responsibility of the Space Shuttle until it was retired last July. "At the moment, the USA has no way of delivering human beings to the space station," says Dr Chris Welch from the International Space University in Strasbourg, France. "The only way to get there is on Russian rockets."

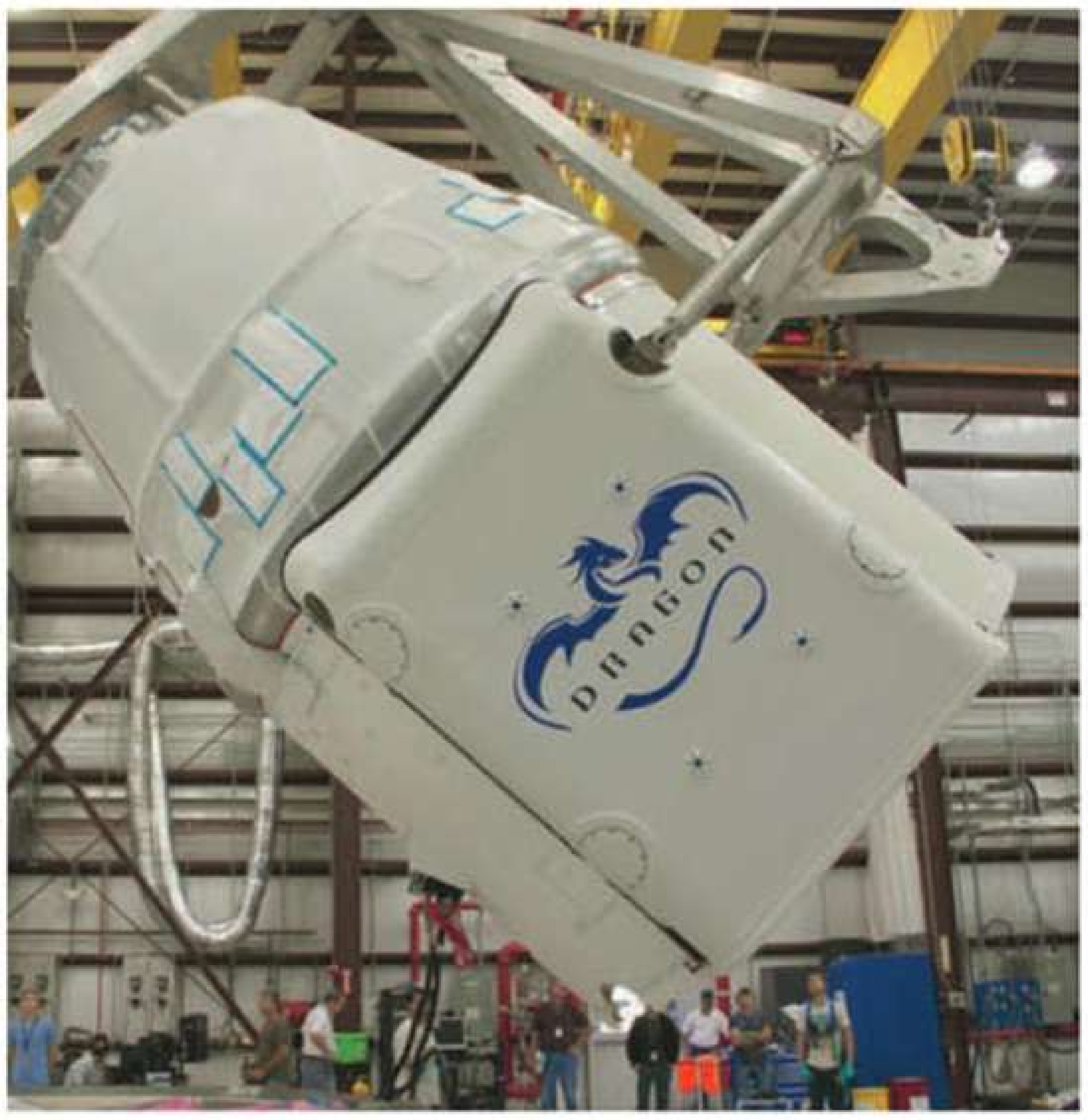
Last year NASA awarded SpaceX $75 million to help it adapt Dragon for astronauts by developing a 'launch escape system' that would carry the crew to safety in the event of an emergency using eight rockets built into the walls of the craft. But SpaceX faces competition from several other companies vying to carry astronauts to the ISS, including Boeing and Sierra Nevada Corporation.

No matter who is awarded the contract to transport astronauts, the future of spaceflight is looking increasingly commercial. "There's a gradual move in that direction," says Welch. "In general, if you open things up to the market, prices come down. SpaceX is one of the companies focused on bringing down the cost of access to space."

"It's a relatively new company, but very ambitious," he adds. "Elon Musk has announced he wants to retire on Mars." ■

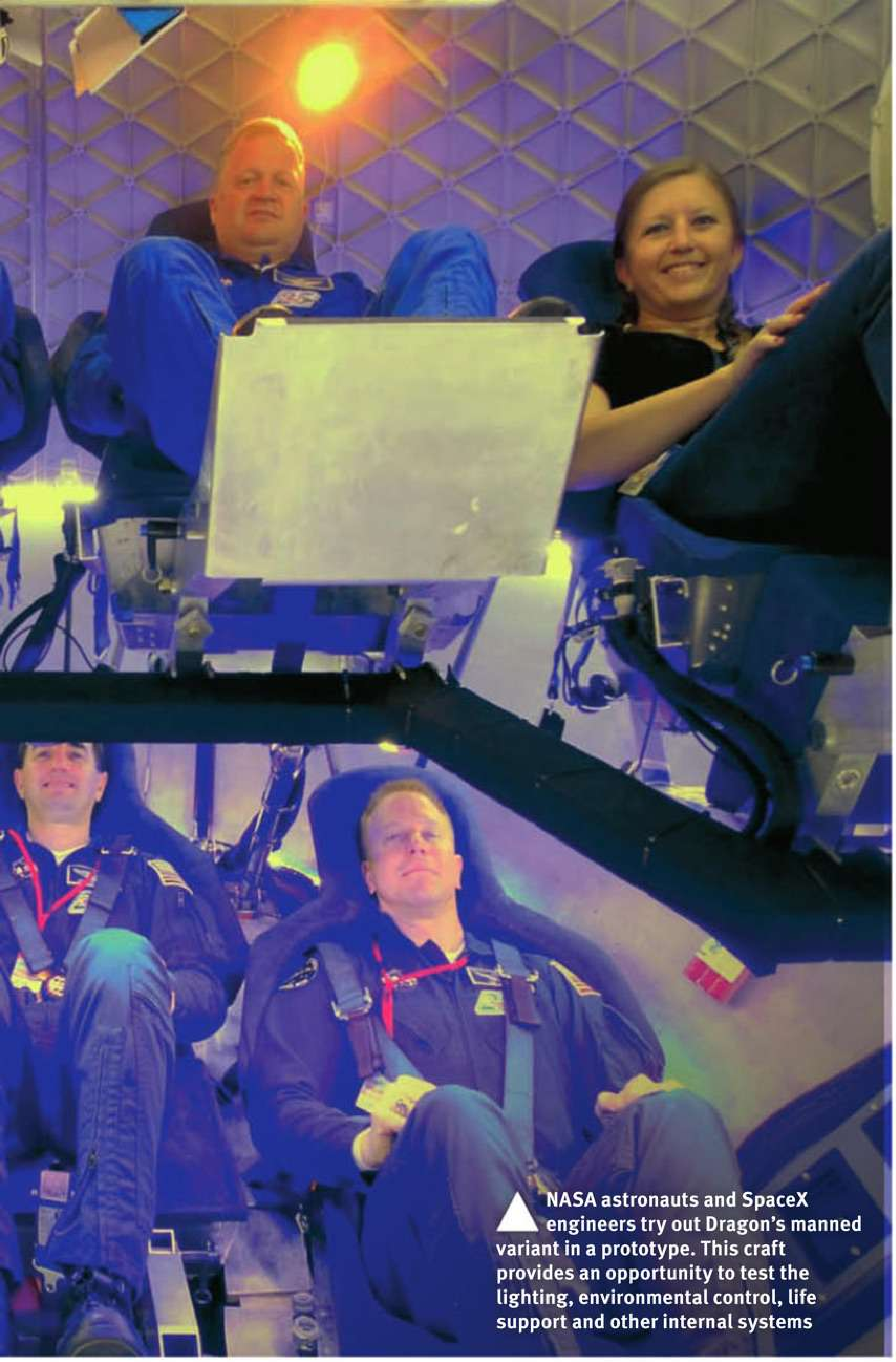
"It's a very ambitious company; Elon Musk has announced he wants to retire on Mars"

Dr James Lloyd is a freelance science writer and blogger



◀ The Dragon is rotated before being fixed to the Falcon 9 rocket. The top section is the ballistic capsule that carries the cargo. Underneath is the trunk, which houses two solar arrays. The capsule is reusable but the trunk is jettisoned before re-entry, burning up in the Earth's atmosphere

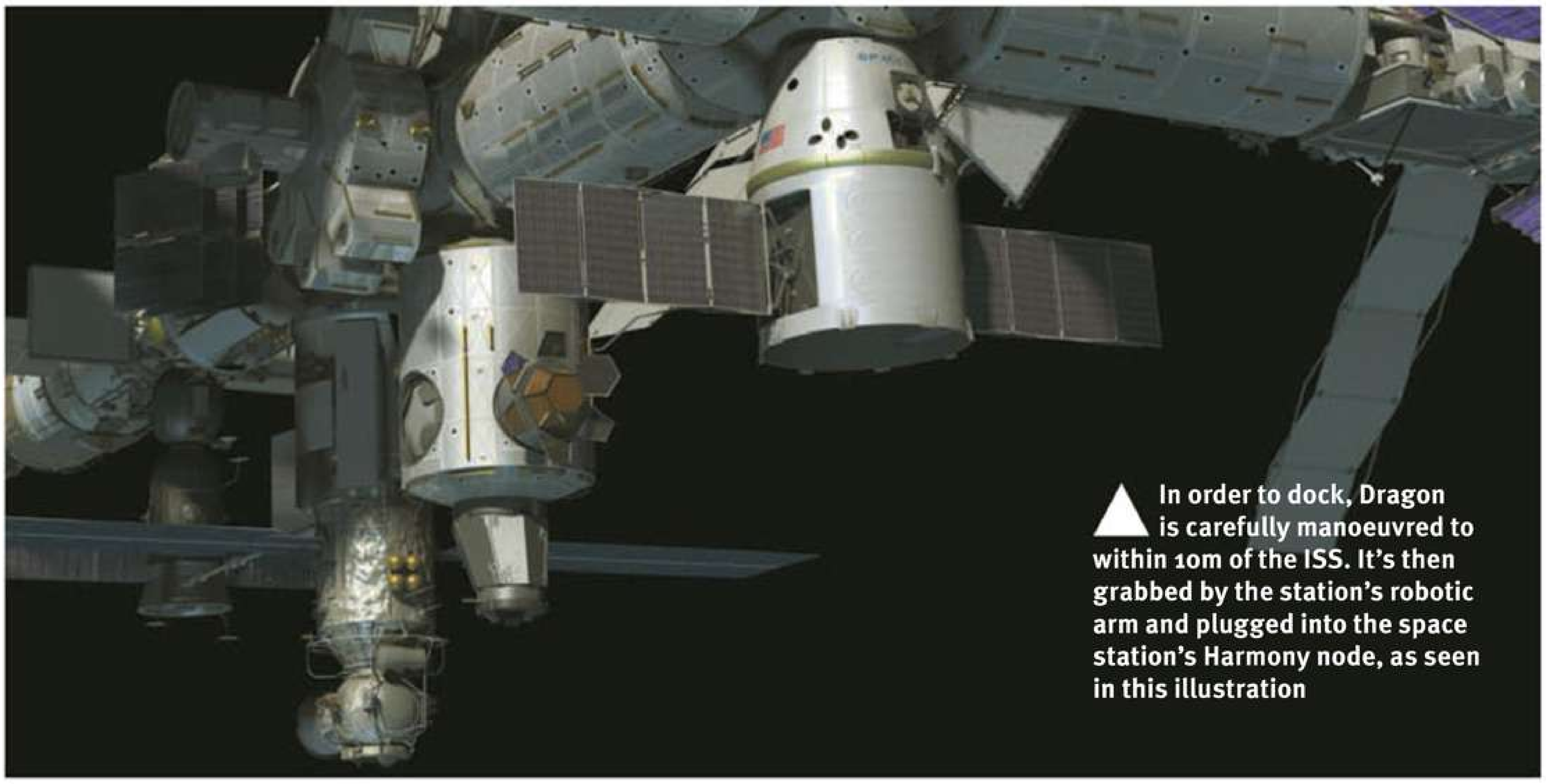
NASA/KSC X5



NASA astronauts and SpaceX engineers try out Dragon's manned variant in a prototype. This craft provides an opportunity to test the lighting, environmental control, life support and other internal systems

Cargo is prepared to be loaded into the Dragon capsule. For the test mission, these packages contain 540kg of non-critical supplies for the ISS astronauts such as extra food, water and clothes

The 55m-tall Falcon 9 rocket, with the Dragon spacecraft perched on top. The rocket falls away in two stages and SpaceX eventually hopes to cut costs by making both stages reusable



In order to dock, Dragon is carefully manoeuvred to within 10m of the ISS. It's then grabbed by the station's robotic arm and plugged into the space station's Harmony node, as seen in this illustration

GETTY

ILLUMINATING LIFE

Since its discovery 50 years ago, Green Fluorescent Protein has become one of the most useful tools in biology. **Zoe Cormier** shines a spotlight on this glorious, glowing molecule

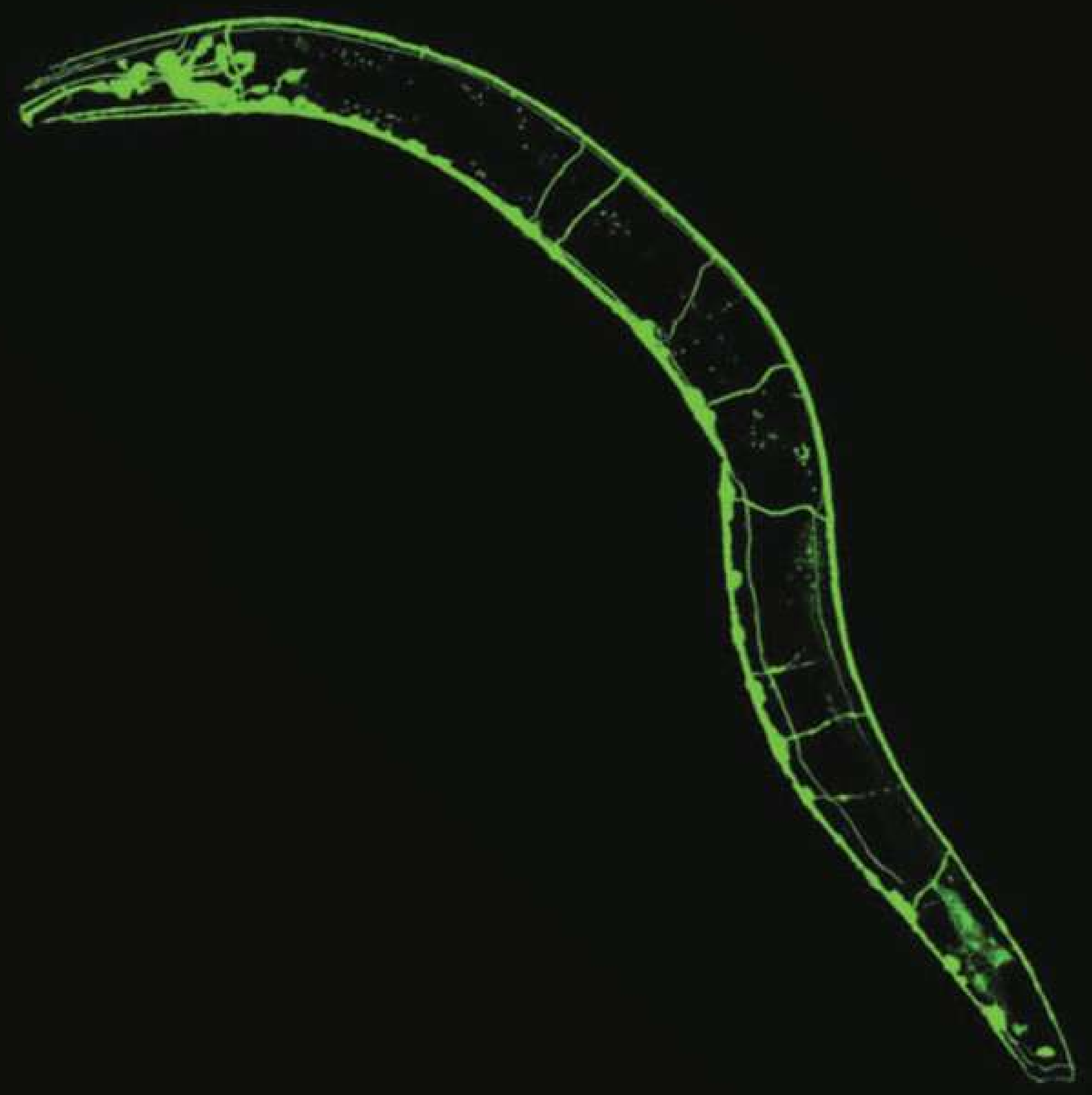
Japanese scientist Osamu Shimomura reported in 1962 that he had extracted a glowing protein from the jellyfish *Aequorea victoria* (pictured). Since then, researchers have used green fluorescent protein (GFP) to shed light on every corner of biology, from the brain's complex circuitry to the spread of cancer.

"We knew that, if it worked, it would be very powerful," says Professor Roger Tsien of the University of California, San Diego. "It was surprising how easy the jellyfish made it for us." In 2008, Shimomura, Tsien and another biologist Martin Chalfie (see 'Reporter Gene', p48) were awarded the Nobel Prize in Chemistry for their work on GFP.

To isolate the protein, Shimomura collected over 10,000 jellyfish (each 5cm in diameter) from the Pacific Ocean, trimmed away their glowing organs, and filtered the marine goo to extract the glowing molecule. Then in the 1980s, his team would gather 50,000 jellyfish to extract a measly 150 milligrams of the molecule. As Shimomura recounted in his Nobel acceptance speech, "Our laboratory looked like a jellyfish factory and was filled with the jellyfish smell."

Understanding the chemistry of GFP became Shimomura's life's work, but it remained useless for 30 years until researchers managed to read the DNA sequence of the jellyfish gene and create a copy through cloning. Biologists could then genetically modify organisms to produce the glowing protein, inserting cloned GFP genes into their DNA. When the GFP gene is inserted next to another gene, it's switched on at the same time, producing the glowing protein. The gene therefore acts as a 'reporter', producing a protein that glows green to indicate when and where its neighbouring gene is active.

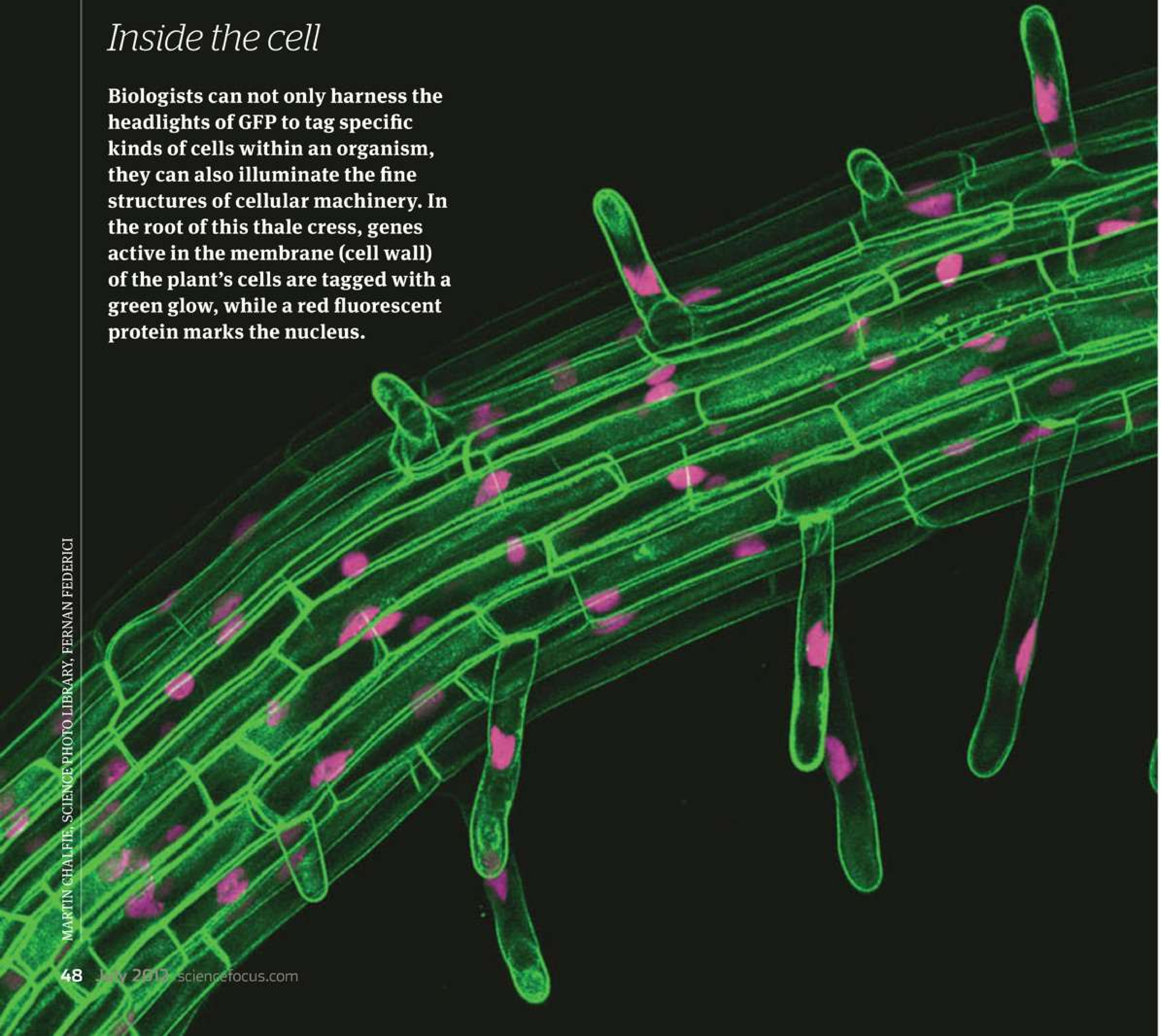
Tsien earned his share of the Nobel Prize by mutating the GFP gene to create a palette of colourful proteins. "I didn't appreciate how many colours would be developed," he says. "But once they became available, people used them beyond anything I could have thought of." ▶



Highlighting genes

Green fluorescent protein glows bright green under blue and UV light. Biochemist Douglas Prasher, who cloned the gene that encodes the protein in 1992, was the first person to recognise GFP's potential to revolutionise biology as a 'reporter gene' that illuminates the activity (expression) of neighbouring genes.

Once the jellyfish gene had been cloned, it could be implanted into new species and used to light up specific groups of cells – enabling biologists to monitor the mechanics of life in real-time. Martin Chalfie showed this was possible by highlighting nerve cells in the nematode worm *Caenorhabditis elegans* (pictured).



Inside the cell

Biologists can not only harness the headlights of GFP to tag specific kinds of cells within an organism, they can also illuminate the fine structures of cellular machinery. In the root of this thale cress, genes active in the membrane (cell wall) of the plant's cells are tagged with a green glow, while a red fluorescent protein marks the nucleus.

MARTIN CHALFIE, SCIENCE PHOTO LIBRARY, FERNAN FEDERICI

Adding red to the mix

Although Roger Tsien managed to develop new forms of GFP in an array of colours – allowing researchers to paint different parts of an organism in a variety of hues – he couldn't produce red. Russian scientist Sergey Lukyanov helped complete the palette by isolating a fluorescent protein from coral, DsRed, pictured here glowing in mosquito larva.

Like GFP, the DsRed gene can be inserted into DNA as a 'proof-of-concept' – to show that an organism could be genetically engineered to activate a gene it wouldn't normally have. For instance, instead of inserting DsRed or GFP, you could add a gene that would stop a mosquito carrying the malaria parasite.

Brainbow

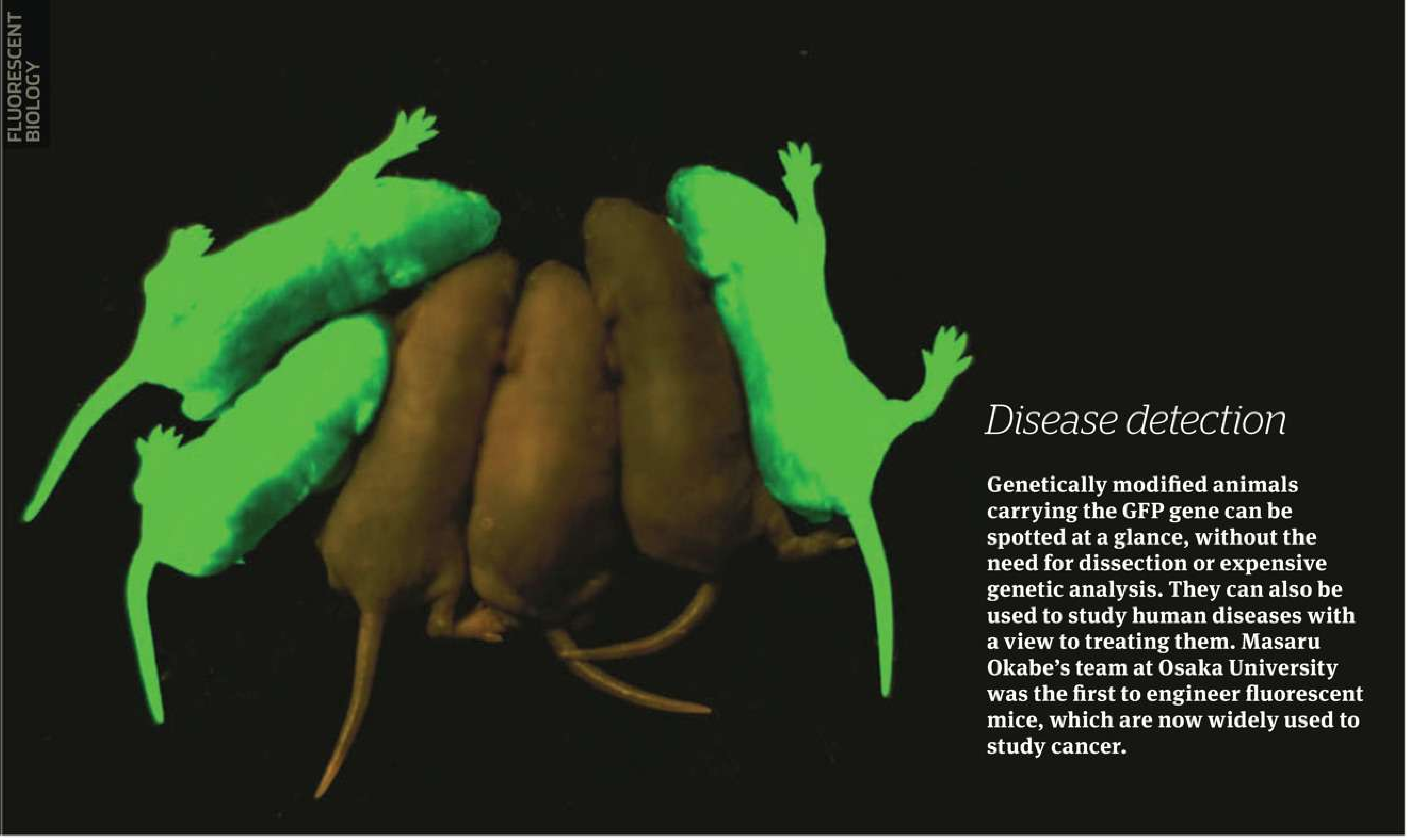
One often-quoted fact is that there are more possible connections between the 100 billion neurones in the human brain than the number of atoms in the Universe. "Each neurone has contact with not just one, but hundreds or even thousands of other neurones," explains Professor Jeff Lichtman of Harvard University. "In order to understand how information flows in the brain, we need to be able to see where the connections lie."

But for decades, neuroscientists had been stymied in their efforts to visualise these dense networks of neurones. Lichtman himself had tried many different approaches, using various chemical stains and dyes in what he describes as 'imaginative but mostly failed ways'. It was Roger Tsien's palette of GFP-like proteins that finally provided the solution needed to crack the biochemical puzzle: with just three different genes for fluorescent proteins – red, green and blue – he could create a huge variety of visible colours.

Similar to the way in which a TV screen seemingly creates any hue from a combination of red, green and blue lights, Lichtman's team developed a breed of genetically-engineered mice whose neurones were programmed to produce a random combination of red, green and yellow fluorescent proteins. The result is a 'brainbow' (pictured), where every neurone of the mouse has a different shade in a technicolour spectrum – more than 90 colours in all.

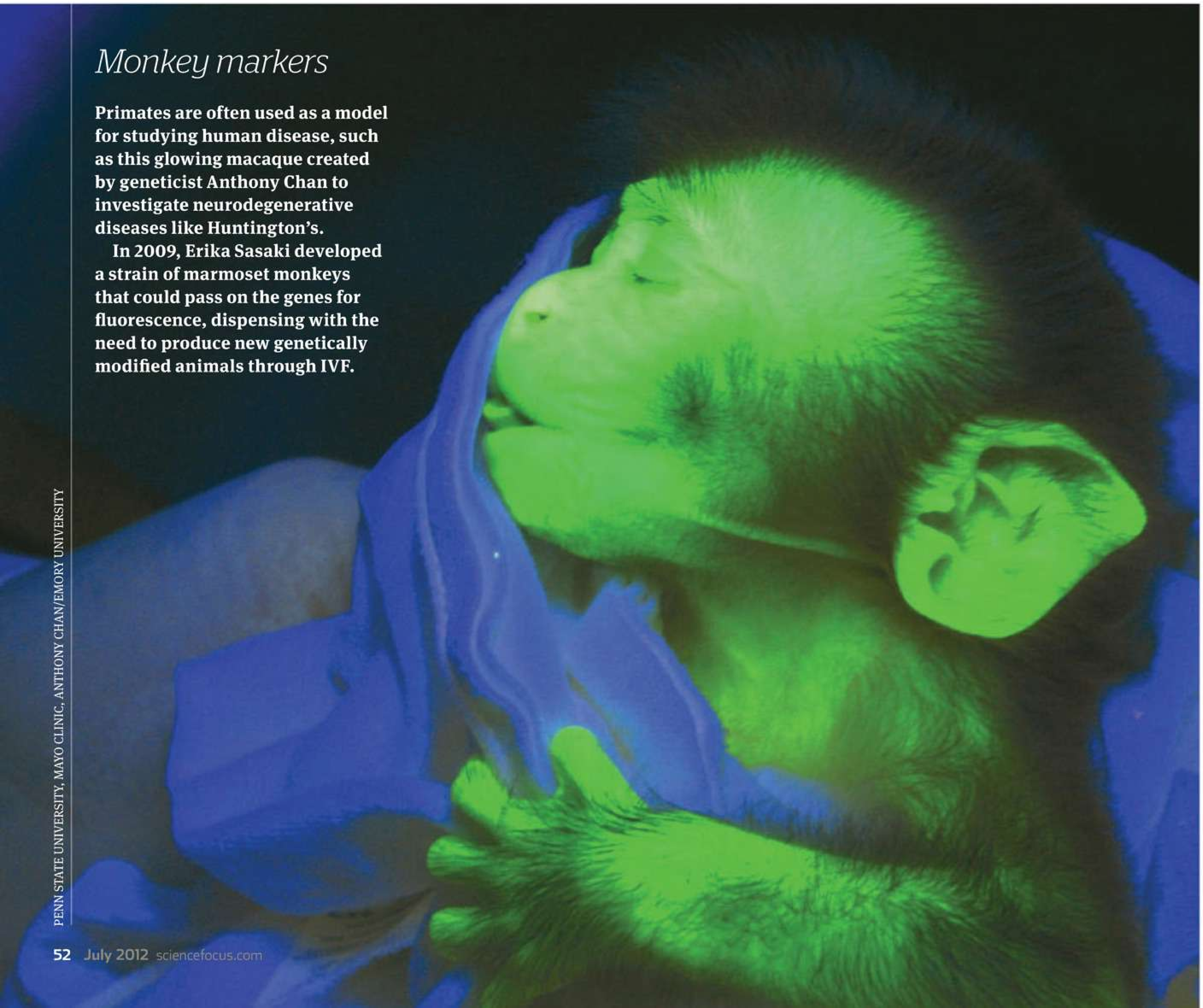
Thanks to this technique, first publicised in 2008, Lichtman has not only been able to map the connections in the mouse brain, he can also observe when specific neurones fire electrical signals to each other. "I can't imagine how I'd be able to look at the patterns of nerve-firing activity without the brainbow," says Lichtman. "I can see patterns in nature I wouldn't otherwise see. GFP is a bit like the Hubble Space Telescope: you use it to look out there, and you see things that you don't understand. But you just have to try and figure out what they mean."

LIVET/WEISSMAN/SANES/LICHTMAN/HARVARD UNIVERSITY



Disease detection

Genetically modified animals carrying the GFP gene can be spotted at a glance, without the need for dissection or expensive genetic analysis. They can also be used to study human diseases with a view to treating them. Masaru Okabe's team at Osaka University was the first to engineer fluorescent mice, which are now widely used to study cancer.

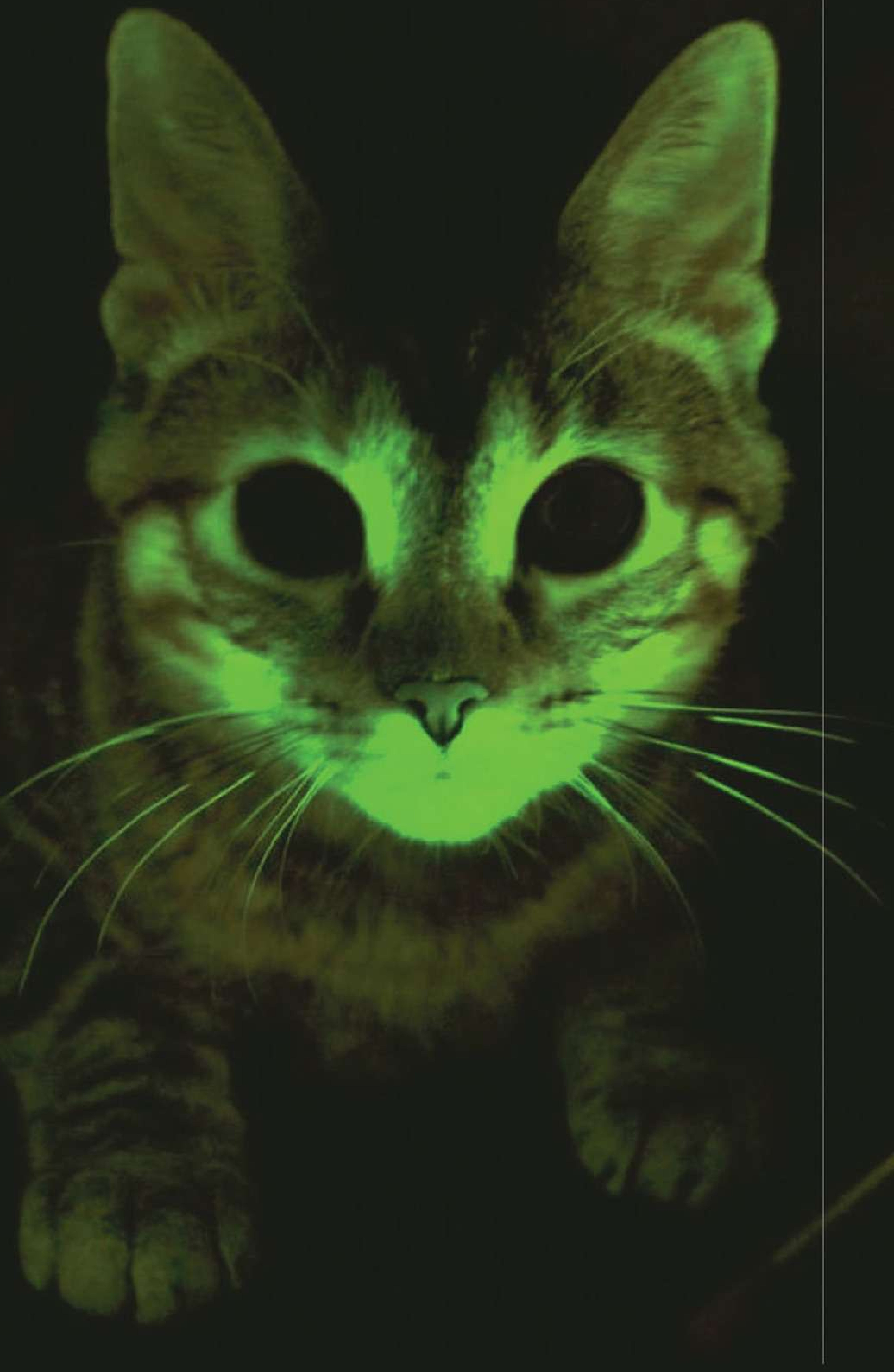


Monkey markers

Primates are often used as a model for studying human disease, such as this glowing macaque created by geneticist Anthony Chan to investigate neurodegenerative diseases like Huntington's.

In 2009, Erika Sasaki developed a strain of marmoset monkeys that could pass on the genes for fluorescence, dispensing with the need to produce new genetically modified animals through IVF.

PENN STATE UNIVERSITY, MAYO CLINIC, ANTHONY CHAN/EMORY UNIVERSITY



From colour to cure

For some HIV researchers, a cure for the disease is no longer an unattainable ideal. "It is a realistic goal," says Dr Eric Poeschla, a physician and virologist at the Mayo Clinic in the US, whose work grabbed headlines last September when his lab announced that it had created a breed of genetically modified glowing green cats designed to be immune to the cat equivalent of HIV, feline immunodeficiency virus (FIV).

There are many variants of the virus in the animal kingdom, including versions that infect horses, cattle and monkeys. But only the feline virus causes AIDS in the same way as in humans, and GFP has allowed Poeschla to breed FIV-resistant cats far more quickly and efficiently than is possible through the arduous methods of traditional cloning. "GFP is easy to monitor and it's remarkably non-toxic – that's the really wonderful thing about it," he explains.

The research is deadly serious: a global pandemic of FIV is affecting millions of cats. "You don't do this kind of work frivolously, you do it because there are worldwide epidemics killing both people and cats."

The next step will be to determine whether the cats are resistant to infection from FIV, with the ultimate goal of understanding if other animals can be rendered immune to their own AIDS viruses. If so, Poeschla hopes the results could be used to design gene therapies that work in humans. ■

Zoe Cormier is a science journalist based in London

SPECIAL REPORT

THE SEARCH FOR MULTIPLE UNIVERSES

Physicists may be on the brink of finding proof that our Universe is not alone. Robert Matthews peers into the multiverse…

Astronomers have a reputation for bringing us awe-inspiring discoveries: new planets, exploding stars, galaxies on the edge of the known Universe. But now they are on the trail of the most mind-boggling finding of all: evidence for a whole new universe beyond our own.

For millennia, philosophers have insisted that everything we see is part of the all-encompassing totality called the Universe. And for centuries, astronomers have been steadily mapping its immensity, using ever more powerful telescopes to probe ever deeper into space. It seemed clear, however, that there had to be a limit to what they could see. Since the discovery of cosmic expansion around a century ago, astronomers believed ▸

ESA/NASA/JPL-CALTECH/STSCI, ILLUSTRATION BY MAGICTORCH

Our Universe could be just one of an unfathomable number of bubble universes that scientists think can collide with each other

DETECTING BUBBLE UNIVERSES

How Planck may prove the Multiverse is real and not just the stuff of science fiction

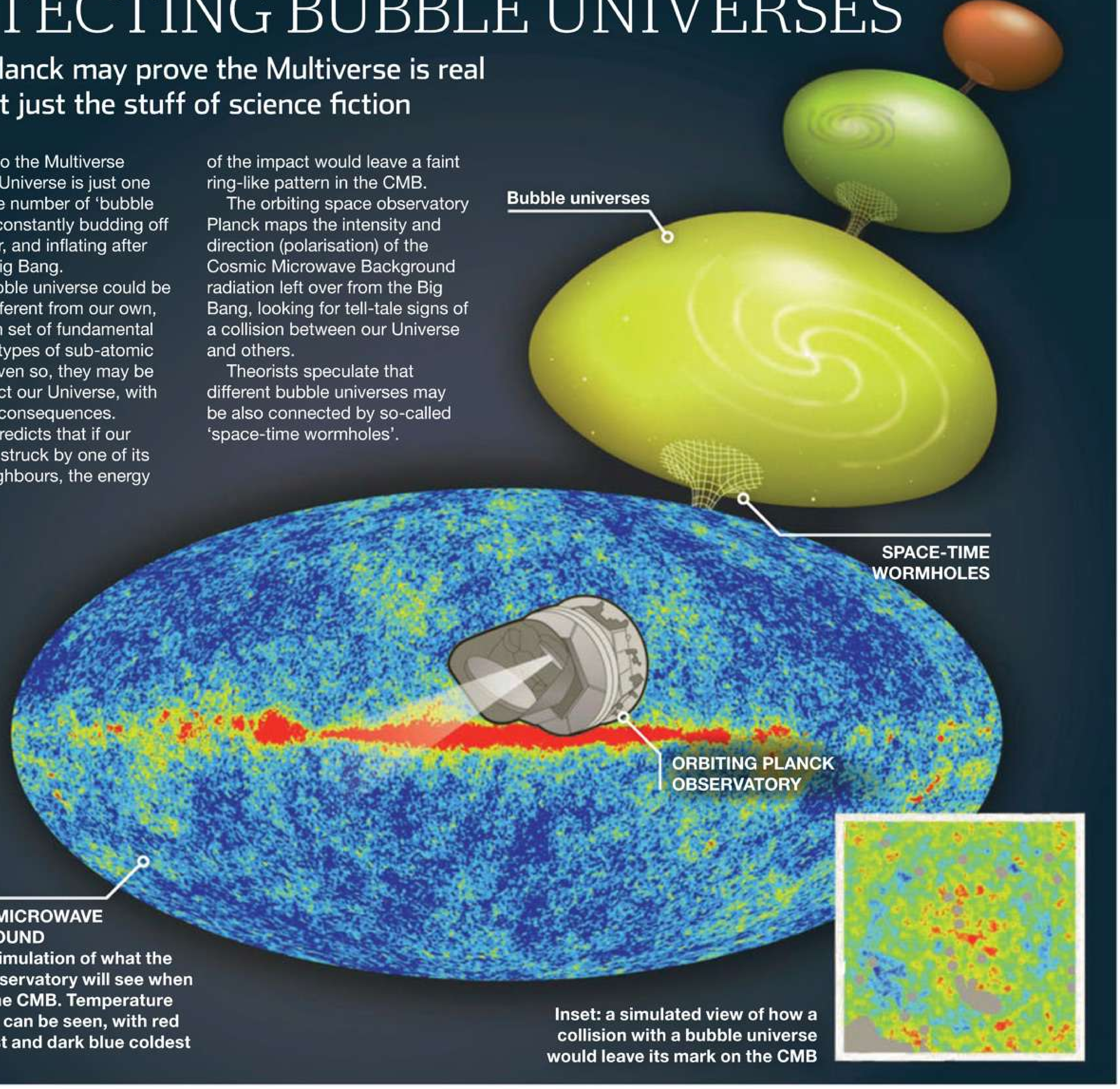
According to the Multiverse theory, our Universe is just one of an infinite number of 'bubble universes' constantly budding off one another, and inflating after their own Big Bang.

Each bubble universe could be radically different from our own, with its own set of fundamental forces and types of sub-atomic particles. Even so, they may be able to affect our Universe, with detectable consequences.

Theory predicts that if our Universe is struck by one of its cosmic neighbours, the energy of the impact would leave a faint ring-like pattern in the CMB.

The orbiting space observatory Planck maps the intensity and direction (polarisation) of the Cosmic Microwave Background radiation left over from the Big Bang, looking for tell-tale signs of a collision between our Universe and others.

Theorists speculate that different bubble universes may be also connected by so-called 'space-time wormholes'.



COSMIC MICROWAVE BACKGROUND
This is a simulation of what the Planck observatory will see when it scans the CMB. Temperature variations can be seen, with red the hottest and dark blue coldest

Inset: a simulated view of how a collision with a bubble universe would leave its mark on the CMB

► there must be a final frontier, an ultimate barrier beyond which objects were receding so fast their light would simply never reach us.

But now there's mounting excitement that it may be possible to probe beyond this far horizon, and that there is more – much more – beyond it. According to the latest theories of the forces that rule the cosmos, what has been regarded as the Universe may in fact be just one of an infinite number making up something far grander: the true universe – or Multiverse.

And, no less amazing, astronomers believe that an orbiting observatory, launched in 2009 by the European Space Agency, may be able to reveal the Multiverse. Named Planck, after the eponymous German pioneer of modern physics, it carries instruments that measure the radiation left over from the Big Bang 14 billion years ago. Since its discovery in the mid-1960s, the properties of that radiation, known as the Cosmic Microwave Background (CMB), have been used to reveal a host of features about our own Universe, such as its age, size and density. Now astronomers think it may do even more, revealing the presence of other universes beyond our own.

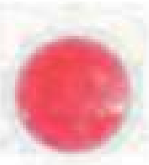
NEED TO KNOW: *INFLATION*

A kind of anti-gravitational force emerging out of empty space that triggered the Big Bang. It could also lead to the creation of countless other universes as well as our own.

Stephen Feeney, an astronomer at University College, London, says: "Observations of the CMB strongly support the idea that our Universe began with a period of exponentially fast expansion now called 'inflation'.

"Current theories in high-energy physics suggest not only that inflation is possible, but also that it means our Universe may be just one of a vast

GETTY, ILLUSTRATION BY ACUTEGRAPHICS



number of expanding ‘bubbles’, which together make up what we call the Multiverse.”

Strings create bubbles

These theories centre on attempts to create a so-called Theory of Everything, a single set of equations that describe all the forces at work in our Universe, together with all the different types of particle. Creating such a theory has been the Holy Grail of theoretical physics, but one that eluded even Einstein.

Now there is a growing belief that the Theory of Everything’s foundations lie in so-called String theory. According to this, the vibrations of bizarre multidimensional things known as strings lead to the forces and particles we observe. Despite being incredibly small, strings are expected to have implications for the entire Universe, says theorist Dr Matthew Johnson of the Perimeter Institute, Canada: “Any theory – like String theory – that is consistent with what we observe today almost inevitably gives rise to the phenomenon of eternal inflation – and therefore to the Multiverse.” Put simply, that’s because theories involving strings allow anti-gravitational force fields to emerge literally out of nowhere, each spawning ‘bubble universes’, which themselves give birth to yet more, leading to an ever-growing Multiverse.

NEED TO KNOW:
STRING THEORY
This is widely believed to be the best candidate for the Theory of Everything, in which both particles and forces in the Universe are seen as vibrations of multi-dimensional entities called strings.

Not surprisingly, String theory has provoked huge controversy. One long-standing puzzle has been the fact that it allows strings to take up a colossal number of different arrangements, each leading to forces and particles with wildly different properties. According to some estimates there are at least 10^{500} combinations.

“We need to take the possibility that we inhabit a Multiverse very seriously”

This unimaginably vast number of possibilities, known as the String Landscape, is hardly what one expects of the single, unified Theory of Everything.

Yet some theorists now think this may actually be a sign that String theory is on the right track. Perhaps, they argue, that huge number is String theory telling us there are 10^{500} different types of Universe out there somewhere – each one an inflating bubble in the overall Multiverse.

Johnson concedes this is all pretty mind-bending stuff, but adds: “At least in my opinion, we need to take the possibility that we inhabit a Multiverse very seriously.” Like any scientist, however, he also accepts that neat ideas are not enough. For any theory to command respect there has to be hard, observational evidence – and that is what Johnson, Feeney and others now hope to get from Planck.

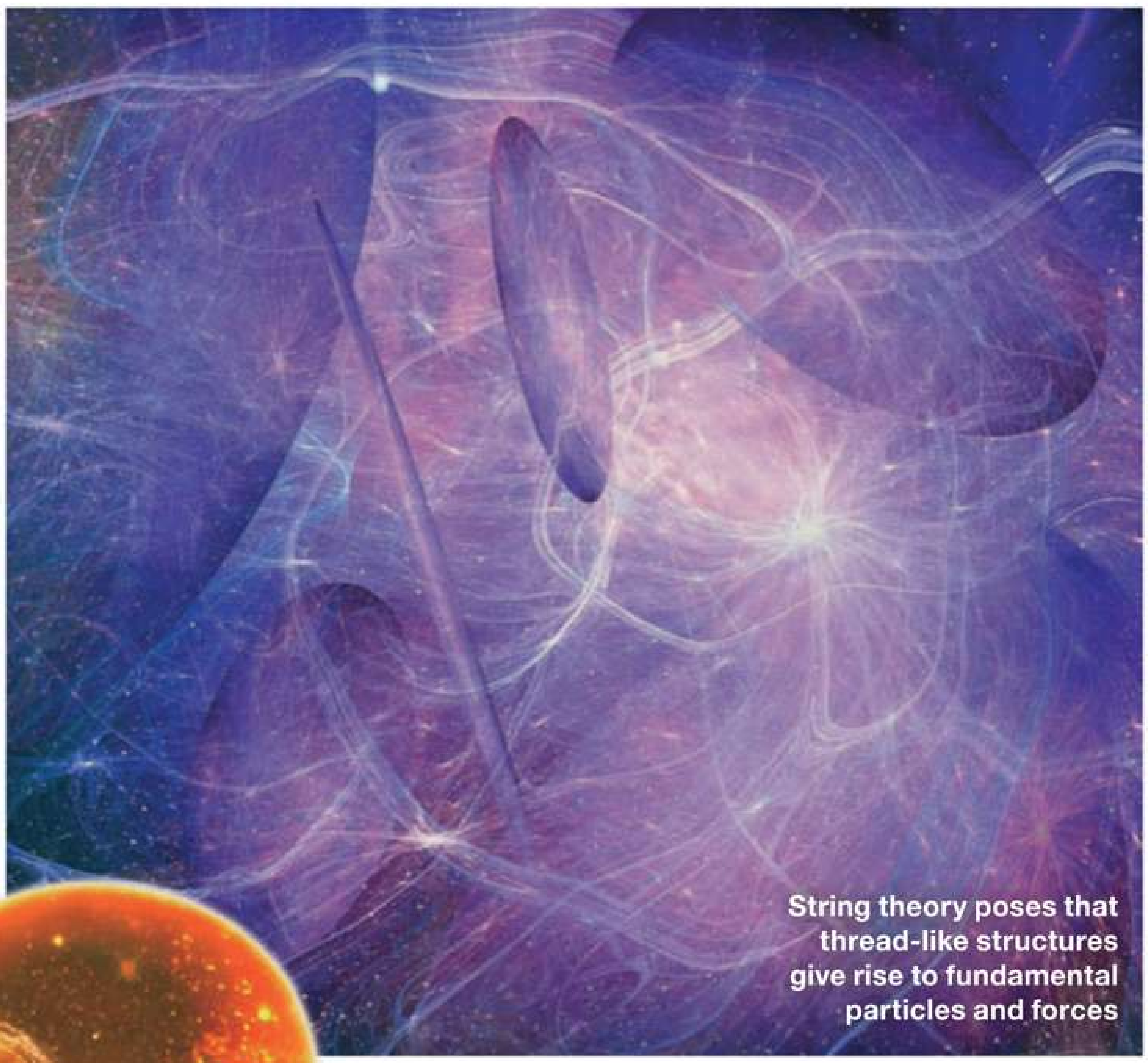
NEED TO KNOW:
THE LANDSCAPE
The range of different universes that are allowed by attempts to create a Theory of Everything. Estimates put the number of universes at around 10^{500}.

Colliding universes

They are part of an international team now carrying out incredibly complex calculations and computer simulations to predict what might happen when bubble universes interact with each other. And there’s one interaction you don’t need a PhD to envisage happening: our Universe being smashed into by another.

Finding evidence of just such a cosmic crash is what researchers are now focusing on. They think that such collisions are pretty much guaranteed to take place. What isn’t clear is whether one has occurred in the 14 billion years that our particular bubble, our Universe, has existed. If there has been a cosmic collision in that time, it must have been a pretty gentle one, otherwise there would be no theorists – or anyone else – left to discuss the possibility.

Given such constraints, researchers have begun sketching out the ►



String theory poses that thread-like structures give rise to fundamental particles and forces

HOW THE MULTIVERSE EXPLAINS OUR EXISTENCE

If many universes are out there it increases the chances of 'goldilocks' conditions

One of the biggest controversies in science might be resolved by the Multiverse concept: why are conditions in our Cosmos just right for humans? Scientists have long been intrigued by the fact that if fundamental forces and particles making up our Universe have even slightly different properties, human life would be impossible. For example, if the electromagnetic force were just a few per cent weaker, hydrogen atoms could not exist – and neither could we. On the other hand, if the so-called weak nuclear force were much stronger, supernova explosions could not create the chemical elements needed for life.

This has led to the emergence of the so-called Anthropic Principle, according to which our existence gives clues to what the Universe must be like. In the 1950s, the brilliant British astrophysicist Fred Hoyle used the Anthropic Principle to predict the existence of an esoteric property of carbon atoms, without which exploding stars could not make these key components of living organisms. More recently, the Nobel Prize-winning physicist Professor Steven Weinberg used the idea to predict the existence of Dark Energy.

One possible explanation for the fact that the properties of our Universe are just right for human existence is that it's not just a coincidence – it's actually evidence that the Cosmos has been specially created just for us. This quasi-religious idea is anathema to many scientists, so it leaves them needing an alternative. According to some theorists, this is where the Multiverse comes in. In just the same way as it's possible to roll an 'incredible' six sixes on the trot given enough attempts, the literally infinite size of the Multiverse makes it inevitable that it contains regions whose conditions are suitable for human life.

Indeed, according to theorist Professor Max Tegmark of the Massachusetts Institute of Technology, the sheer size of the Multiverse means other beings identical to us also exist out there. There's little risk of meeting them, however. According to Tegmark, the distance you'd have to travel is so great that the number of kilometres has more digits after it than particles in the known Universe.

NEED TO KNOW:
Anthropic principle
A means of deducing properties of the Universe – such as the strength of the fundamental forces within it – using the fact that our Universe contains observers, namely, us.

Fred Hoyle coined the term 'Big Bang' as an insult – he was actually a proponent of the Steady State theory of the Universe

SCIENCE PHOTO LIBRARY, CORBIS

▶ telltale signs of a cosmic collision they think may still be detectable with Planck. Such a collision should leave its mark on the so-called Cosmic Microwave Background (CMB) radiation of our Universe. This radiation has its origins in the Big Bang, and for the first 400,000 years was in intimate contact with the particles filling the early Universe. After that time, the radiation and matter evolved separately, with the CMB remaining as a snapshot of how matter was spread around the Universe just after the Big Bang. It's a snapshot being examined in unprecedented detail by Planck.

According to Feeney, previous studies of the CMB have shown that it is astonishingly smooth and even – just as expected if inflation took place in our Universe. Calculations suggest, however, that this smoothness would be affected if another universe had run into our one, the pulse of energy producing a faint ring-like pattern that may still be detectable today (see 'Detecting bubble Universes', on p56).

Attempts to find such patterns in existing data have already been made, so far without success. The European Space Agency is now preparing to release fresh data from Planck over the coming months, which will be scrutinised by astronomers world-wide. Feeney cautions that the odds of finding evidence for a collision are pretty long. "But even if we don't see anything, we can still put constraints on our theories," he explains. "For example, we could rule out theories predicting large numbers of observable collisions."

Other scientists are looking for further evidence for cosmic collisions in the microwaves detected by Planck, such as their polarisation – roughly speaking, their direction of vibration.

NEED TO KNOW:
Bubble universe
One of the infinite number of baby universes constantly being created throughout the Multiverse, of which our Universe was just one when it formed 14 billion years ago.

According to Associate Professor Matthew Kleban of New York University, a collision would create a "wake" of matter travelling through our Universe off which the microwaves would scatter, like sunlight off rippling water. And this would leave them polarised. "Planck will provide full-sky polarisation information that could help corroborate or exclude some of the features as bubble collisions," says Kleban.

The Dark Flow

Planck is not the only source of evidence for the Multiverse, however. A team of astronomers led by Dr Sasha Kashlinsky of the NASA Goddard Space Flight Center in Maryland, may have already found direct evidence in the form of the so-called Dark Flow.

As its name suggests, this is a tide-like motion of whole clusters of galaxies through space, over and above that caused by the cosmic expansion. And something appears to be dragging them at speeds in excess of a million kilometres per hour towards the constellations Centaurus and Vela.

There's still considerable debate about whether the Dark Flow is real or the result of flawed data analysis. But if the evidence continues to stack up, it suggests that there may be another universe out there, the gravity of which is tugging at ours. "This would be the simplest explanation of the Dark Flow, in my opinion," says Kashlinsky.

Some researchers think evidence for the existence of the Multiverse might turn up much closer to home, at the Large Hadron Collider (LHC) near Geneva. At the University of North Carolina, theorist Professor Laura Mersini-Houghton and her colleagues have been investigating how the Multiverse might affect the Higgs boson, the long-sought particle held responsible for imbuing others with mass. Calculations by the team suggest that the origins of the Higgs lie in a much more massive particle that exists in the Multiverse, which can only be detected with colliders far more powerful than the LHC can manage. "If the LHC finds that the Higgs particle is a lower energy 'cousin' of a high-energy fundamental particle, then it would be one more piece of evidence for the existence of the Multiverse".

Not everyone is convinced, however. Some researchers insist that the whole idea of the Multiverse is based on wishful thinking by theorists running out of ideas. "They're ending up with things so complicated as to be completely unpredictive, and then arguing 'Well, maybe this is how the world works,'" says physicist Dr Peter Woit of Columbia University, New York.

Even those who take the Multiverse idea seriously caution against getting carried away by ideas like visiting universes. "This is exponentially more speculative than the existence of the Multiverse," says Johnson. He adds that it may also be impossible, given that the laws of physics for our cosmic neighbours might be utterly different from our own.

> *"Evidence for the Multiverse might turn up closer to home, at the Large Hadron Collider"*

Even so, the mere idea we might soon have evidence for the existence of a universe next to ours is mind-bending enough. "When I tell my friends what I'm working on, their reaction is usually 'What?!'," says Feeney. "It's certainly very cool working in this field." ■

Robert Matthews is a visiting reader in science at Aston University

FIND OUT MORE

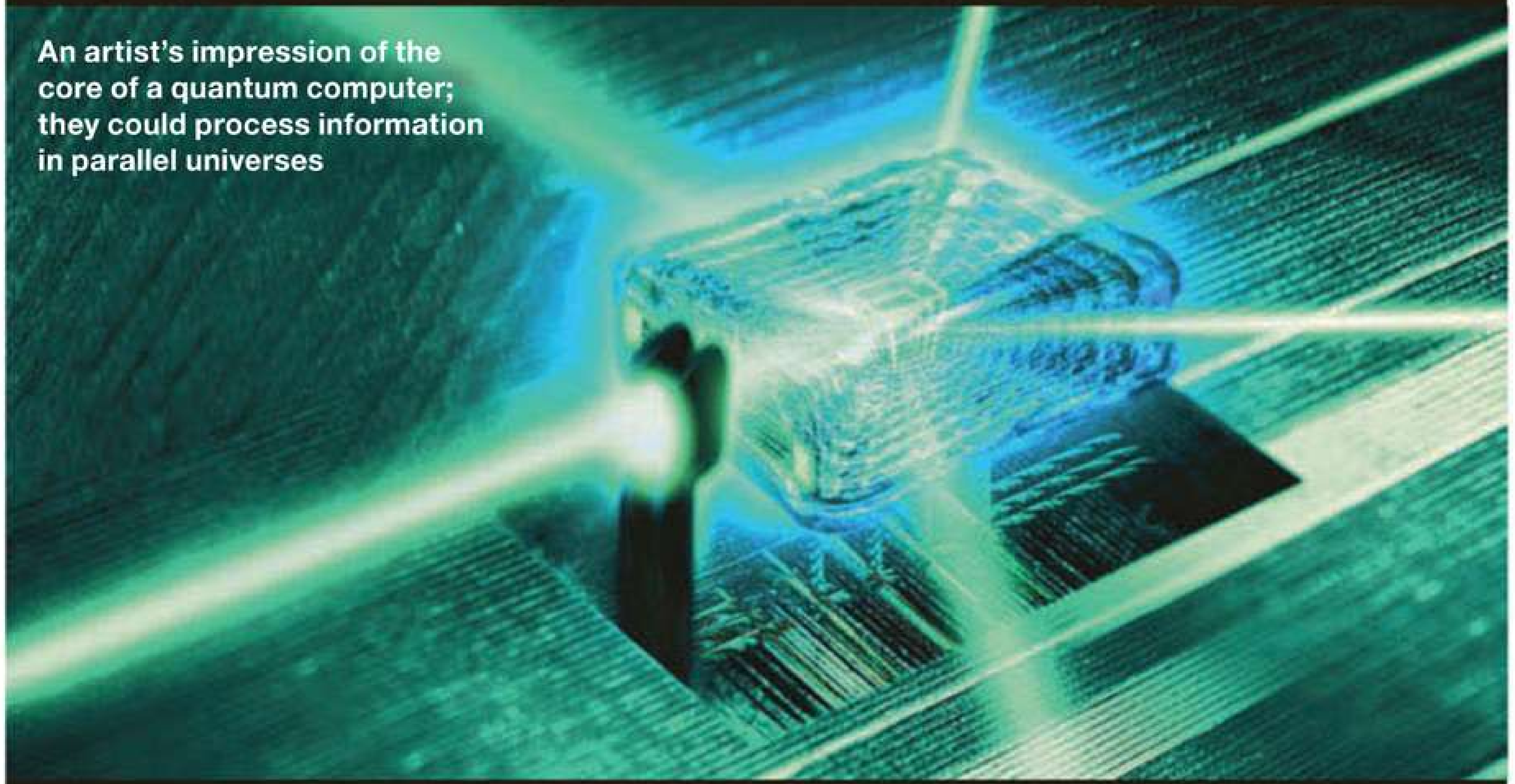
http://vimeo.com/3979661
How Planck is mapping the radiation from the Big Bang

http://n.pr/HViPMY
Podcast looking at how multiple universes might exist

The Hidden Reality
Professor Brian Greene
(Allen Lane, 2011)

A different kind of Multiverse

The theory of the small suggests many coexisting universes



An artist's impression of the core of a quantum computer; they could process information in parallel universes

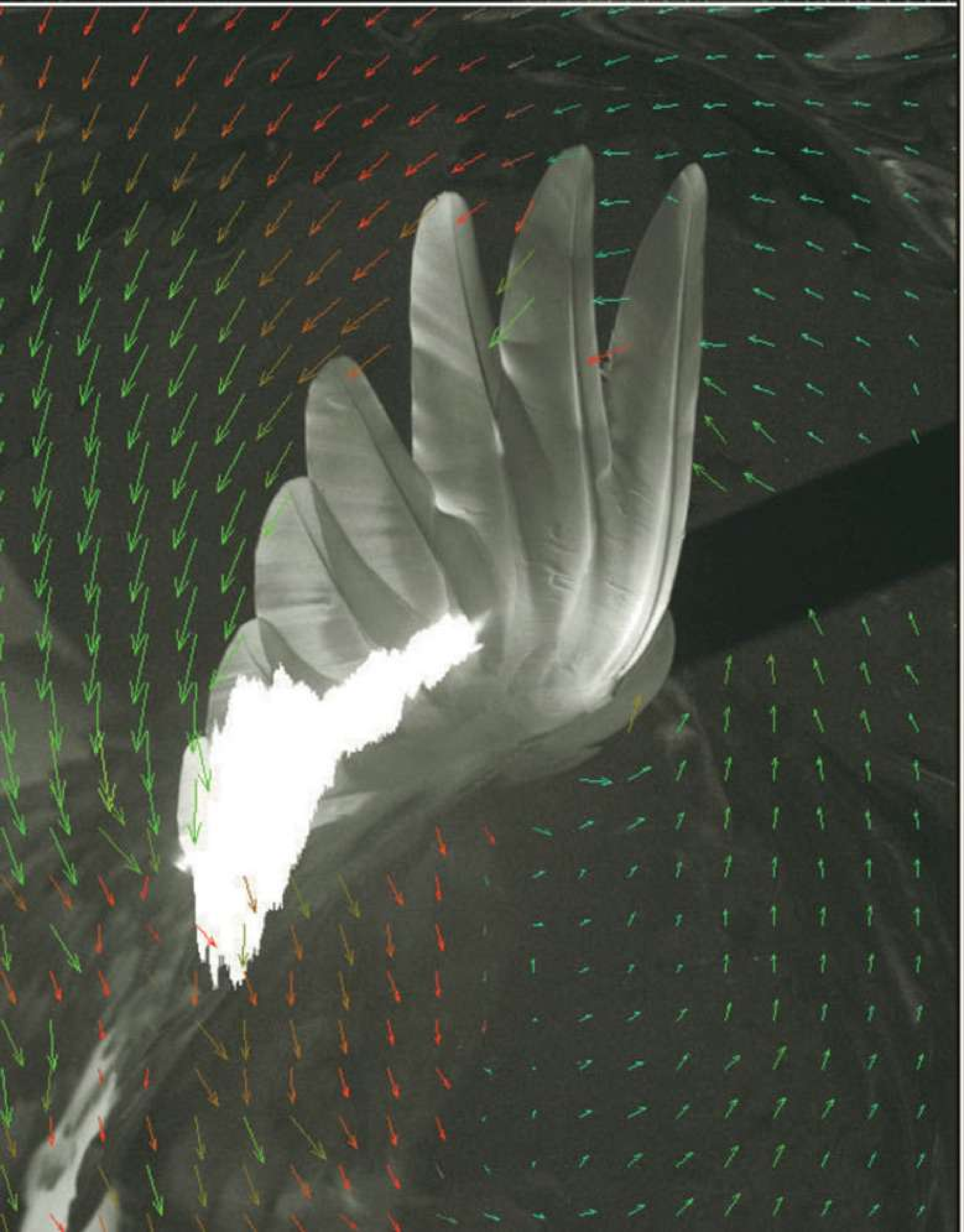
Quantum theory, the equations of which govern the sub-atomic world, has perplexed scientists ever since it emerged over a century ago. One big mystery has been why its equations produce a host of different possible answers, only one of which ever describes the outcome of experiments. What do the other possibilities mean?

For decades, the textbook answer has been that the act of observing the particles eliminates all the other possibilities – though exactly how was never clear. But now a growing number of theorists think the answer may lie in a stunning idea put forward in 1957 by a graduate student at Princeton University. According to Hugh Everett III, all those other outcomes describe events in a vast number of parallel universes that exist alongside our own. Known as the Many Worlds view of quantum theory, it has obvious parallels with the Multiverse idea, but is even more radical – as it implies that these parallel universes aren't trillions of light-years away, but somehow coexist.

Some theorists even claim that ultra-fast quantum computers now being developed may get their speed from carrying out calculations simultaneously in these parallel universes before spitting out the answer in our own.

BRET TOBALSKE X4

At the University of Montana's Flight Laboratory, computers plot the movement of air around birds' wings



BIRD WATCHERS

How are aerial feats achieved in nature? **Sarah Castor-Perry** swoops in on the secrets of flight

With lightweight bodies and an efficient fuel supply, birds are beautifully adapted for flying through the air. Their bones are almost hollow, while their circulatory system delivers a continuous flow of oxygen and nutrients to energy-hungry flight muscles. Thanks to flight, birds have been able to exploit diverse ecological niches, feeding opportunities and nesting sites.

The huge amount of energy required for flight makes it an expensive way to travel. "It's the most costly form of locomotion animals engage in – much more than swimming and running," says Dr Bret Tobalske, director of the Flight Laboratory at the University of Montana. "So it's a unique model for understanding how organisms evolve in relation to that constraint, both behaviourally and physiologically."

Tobalske became interested in birds after life as a carpenter made him concerned about the destruction of forests for timber, and how it was impacting species like woodpeckers. So he joined the Flight Lab, founded in 1988 by Ken Dial, a biologist and proficient pilot who's passionate about birds. "Bird flight is like ballet!" enthuses Professor Dial.

Scientists working at the lab look at all aspects of flight, from the impact of wing shape and skeletal movements, to neural control and oxygen consumption. One of the most vital pieces of equipment is the wind tunnel, which tracks the movement of the air around wings, from those of sizeable swans to the smallest hummingbirds (see p62). The lab also uses pressure-sensitive take-off perches and devices implanted in flight muscles to measure a bird's power, while high-speed ►

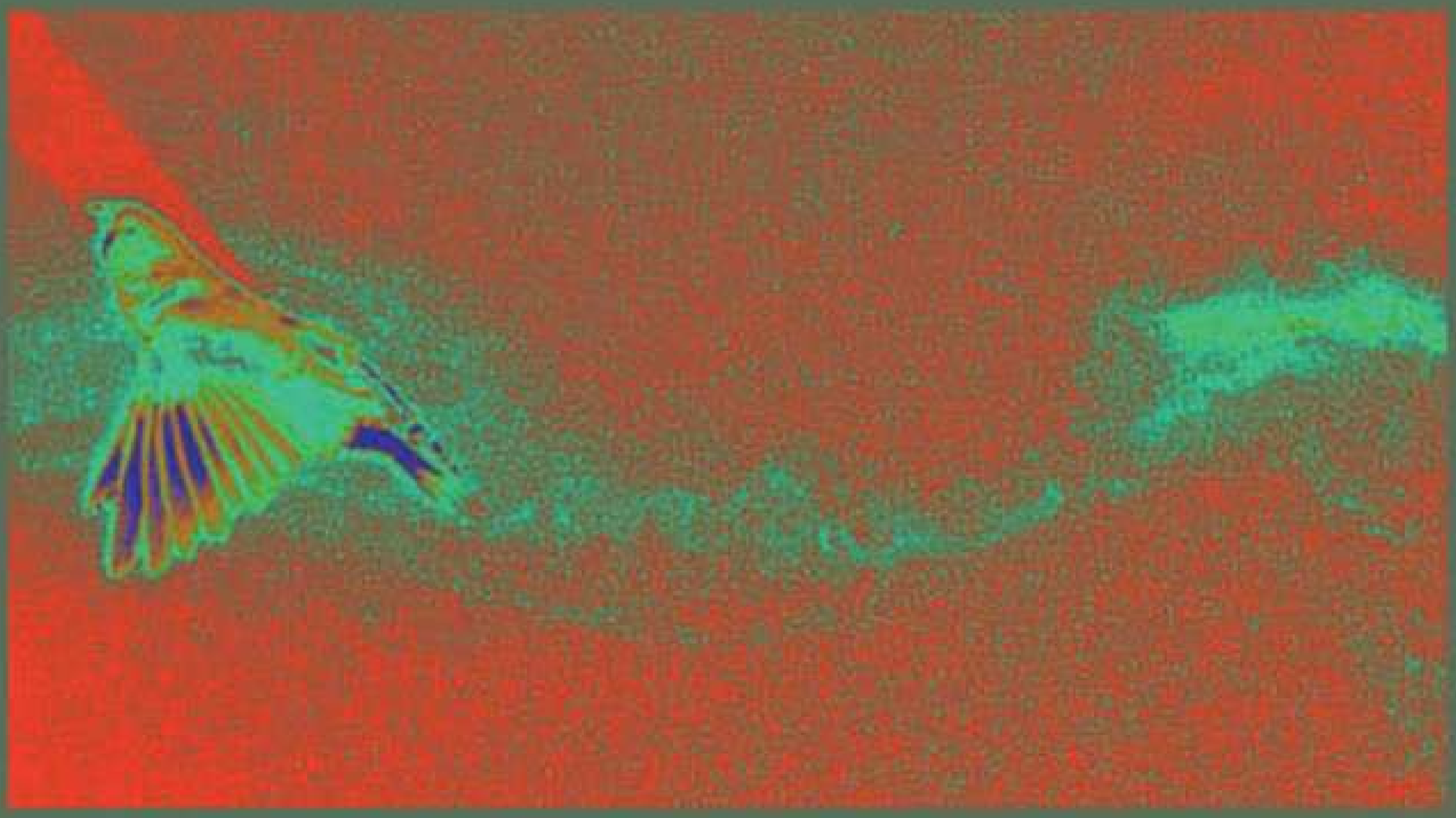
FREQUENT FLAPPERS

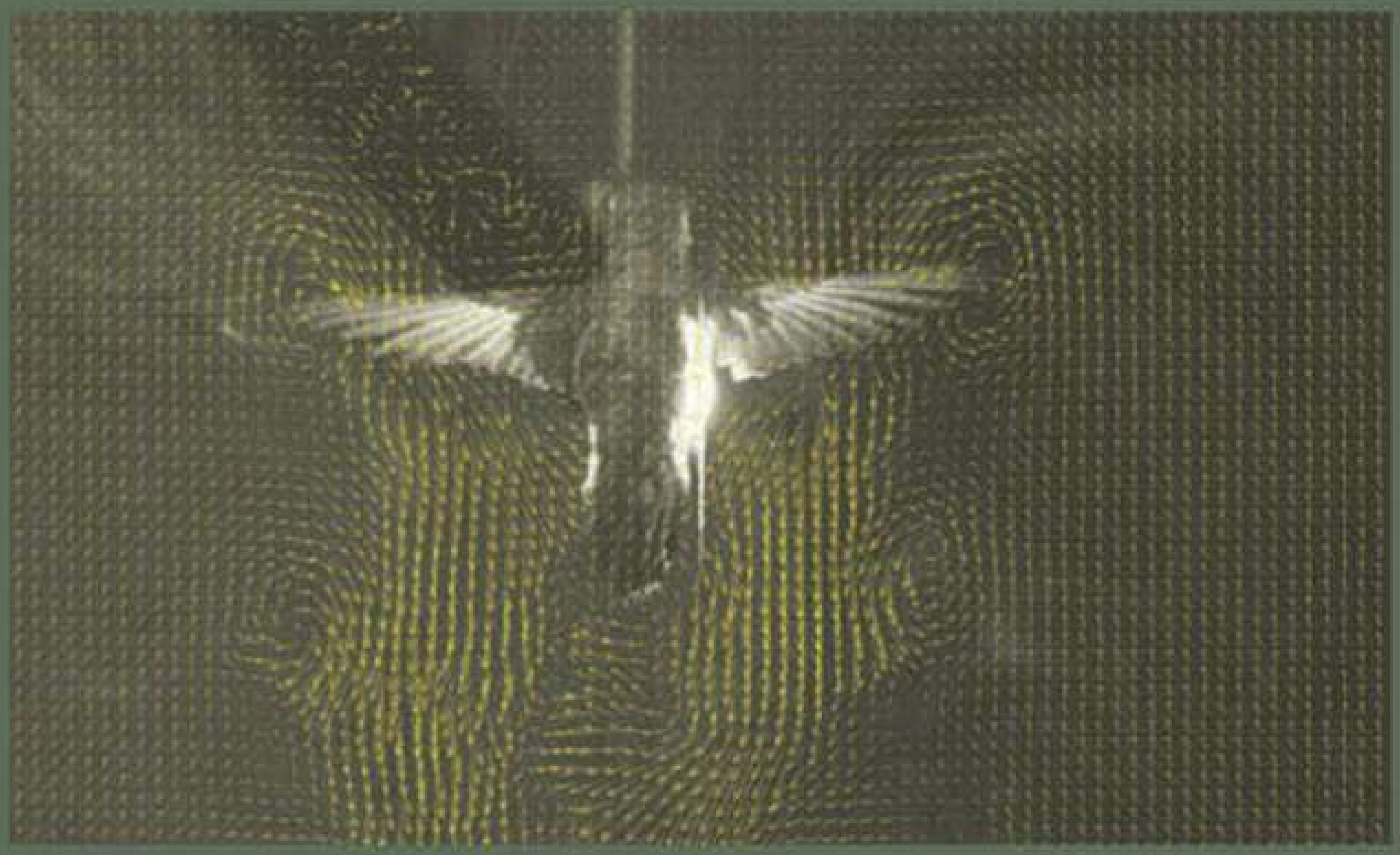
How hummingbirds fly like insects

Out of approximately 10,000 species of birds, hummingbirds are the only ones able to hover in one place indefinitely, moving their wings at a frequency of up to 80 beats per second (80Hz). So why can they flap so much faster than, say, pigeons (8Hz)? "Limb motions are constrained by safety," Bret Tobalske explains. "You couldn't wag a large limb back and forth really fast without damaging it – the muscle would pull off the bone and the ligaments would be damaged." This limit on speed could explain why the biggest hummingbirds are only about 20g, the size of a small parakeet.

In order to study hummingbirds, the Flight Lab uses a laser to illuminate microscopic droplets of olive oil in a chamber. They then calculate the velocity of the oil particles to model how the air moves when a hummingbird beats its wings.

Hummingbirds have evolved remarkably similar flight strategies to the only other animals that can hover indefinitely: insects. Rather than a simple up-down-up flap, hummingbird wings trace a figure of eight – exploiting a phenomenon called 'rotational circulation'. This enables them to generate extra lift as they flip their wings at the end of the downstroke. Using flow visualisation, Tobalske's team were the first to show this phenomenon, which has not been seen in any other vertebrates.





A laser illuminates oil droplets hitting a zebra finch (top); the velocity of each drop is used to model how air moves over its wings. The figure-of-eight pattern created by a hummingbird is shown above

BRET TOBALSKE X3, EYEVINE

► cameras – originally developed by the military – enable researchers to observe how birds control their flight and manoeuvre mid-air.

Results from the Flight Lab are also helping to reveal the origin of bird flight. According to one theory, flight evolved through a 'ground-up' scenario whereby the ancestors of birds flapped to run faster, and eventually took off. The opposite idea is a 'tree-down' origin in which early birds would glide down from high places and then later learned to flap.

If either theory were correct, you'd expect to find intermediate stages, such as modern birds flapping to

> *"It's the most costly form of locomotion animals engage in"*

Bret Tobalske holds a dove in a wind tunnel at the University of Montana Flight Lab

run faster without actually flying. However, Flight Lab's observations have shown that the force generated from a baby bird's wings – with a surface area only a fraction of an adult's – is enough to help them scramble up to elevated refuges.

Flight could have developed from this ability to reach high ground. The flapping behaviour of baby birds – which have tiny wings – shows how an animal could have evolved from something without wings to having a pair large enough for flight, with intermediate stages of partial wings. "People may ask 'What use is half a wing?'" says Dial. "Now we're answering it in spades: we witness this 'flap-running' behaviour to get up slopes in all the groups of birds."

Although bird flight helped inspire one of mankind's greatest inventions, the aeroplane, we haven't yet managed 'biomimicry' and copied nature's amazing aerial abilities. Our aircraft aren't very manoeuvrable, whereas a bird is able to easily move between tree branches, stopping and starting millions of times during its lifetime. "There's a lot to learn," says Dial.

Biomimicry can yield useful applications. The Flight Lab's research could be used to help develop flying robots for military surveillance and for use in search-and-rescue situations, for example.

And perhaps one day we'll be able to produce machines that are even more efficient at flying than a bird. "We're always ready to assume bird flight is optimised and better than what humans could engineer," says Bret Tobalske. "But an engineer can take materials and create something new – animals are dealing with what they've inherited from their ancestors." ■

Sarah Castor-Perry is a science writer and contributes to The Naked Scientists podcast

GAME CHANGER

It's 50 years since the first computer game. **Edward Castronova** argues that they're now having a growing influence on science and the world beyond your TV screen

ILLUSTRATION BY BARRY DOWNARD

Fifty years ago, computer scientists had a tough time justifying the worth of their big, expensive machines. The PDP-1, for example – a 'mini-computer' the size of a wardrobe – cost $120,000, almost $1 million in today's money. To attract funding, researchers needed applications to show off what computers could actually do.

The solution came in 1962, when students at the Massachusetts Institute of Technology produced *Spacewar!*, a two-player game in which you try to shoot an opponent's spaceship. *Spacewar!* was the first video game created for a digital computer and provided a good demonstration of the PDP-1's processing power.

Games have since been the first application for many new ▶

▶ technologies we now use every day. Having undergone something of a social revolution in the last decade, gaming is also having an effect on how we relate to each other.

While gaming is sometimes seen as a solitary pursuit, a study at Brigham Young University in Utah shows that it can actually enhance social connections. Studying the effect of massively multiplayer online games like *World of Warcraft* on marriages, researchers found that in the 76 per cent of the cases where the couple played together, games actually aided the relationship. Couples that game together, stay together.

Games may have other effects on us too. The famous psychologist, Philip Zimbardo, recently spoke out on the subject. In his 1971 Stanford Prison Experiment, in which volunteers were randomly assigned the roles of a prisoner or guard, he showed that human behaviour is heavily influenced by environmental and social pressures. Zimbardo recently suggested that exposing children to morally ambiguous situations in games could be useful in helping them develop their own moral compass.

With the massive rise in mobile gaming, driven by the advent of the smartphone, it would appear that the social impact of games will only increase. Riding a popular trend in casual gaming, some organisations are now applying the principles of game design to non-gaming activities – a process known as 'gamification'.

This often involves making things more like a game by adding elements such as achievements, virtual currency and progress bars. The social networking app Foursquare, for example, offers users points and 'badges' when they use a mobile to check-in at a particular venue.

All the world's a game

Gamification has been applied to everything from improving workplace productivity to the Search for Extraterrestrial Intelligence (SETI). Some argue that gamification could even be used to make the world a better place by offering virtual rewards for playing 'serious games' about important issues. In 2007, game designer Jane McGonigal produced *World Without Oil*, which invited people to live through 32 weeks of a simulated oil crisis. Players shared their interpretations of how their lives would change, and were offered practical solutions on how to adapt.

But the gamification movement has been subjected to criticism.

> *"Games could be useful in helping children develop their own moral compass"*

Serious games aren't particularly fun to play, and they might not deliver a message any more effectively than other approaches. Researchers at the University of South California found that, for delivering information, playing a game has the same effect as web pages (hypertext) or watching a replay of someone playing a game. Pure text is less effective, but it's also much cheaper, so why spend a lot of time and money building a game about an important issue when you could simply write a pamphlet?

The key is making sure the game is addictive, taking advantage of feelings that make us tick. The growth of video games is driven by new technology meeting age-old human motivations, so encouraging people to play *any* game requires the right rewards. After reviewing numerous studies for their book *Glued To Games*, psychologists Scott Rigby and Richard Ryan concluded that games tap into three important feelings that drive us: mastery (feeling that we can successfully accomplish something), relatedness (what we do is part of a larger community) and autonomy (we choose our own fate). Massively multiplayer online role-playing games like *World Of Warcraft* and *Eve Online* meet these criteria.

Games are older than novels, radio and television. But unlike these other

World Of Warcraft: the secret to a happy marriage?

GAMESPRESS X3, BLIZZARD ENTERTAINMENT, UW DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Spacewar! on a PDP-1 computer: the genesis for a gaming revolution

cultural wonders, games aren't a passive experience – they prompt us to actively participate, getting us off the sofa to play virtual tennis using a motion-sensing controller like the Wii or Microsoft's Kinect, for instance. Whether games such as *Wii Fit* always improve physical fitness is debatable, but health experts at Johns Hopkins University found they do improve the wellness of elderly people, while casual games can improve mental health (see 'Brain boosters', p68).

Saving the world

Games clearly have the power to benefit society, but solving some problems will take more than offering virtual rewards through gamification. One possibility is to explore virtual worlds that could enable people to experience and understand ideas that they would otherwise find difficult to imagine.

In some repressed countries, not being aware of the possibilities of democracy can hinder political change, so a game about society – populated by real people and open to all – could help test how different cultural, religious and ethnic backgrounds and assumptions could be brought together in peace.

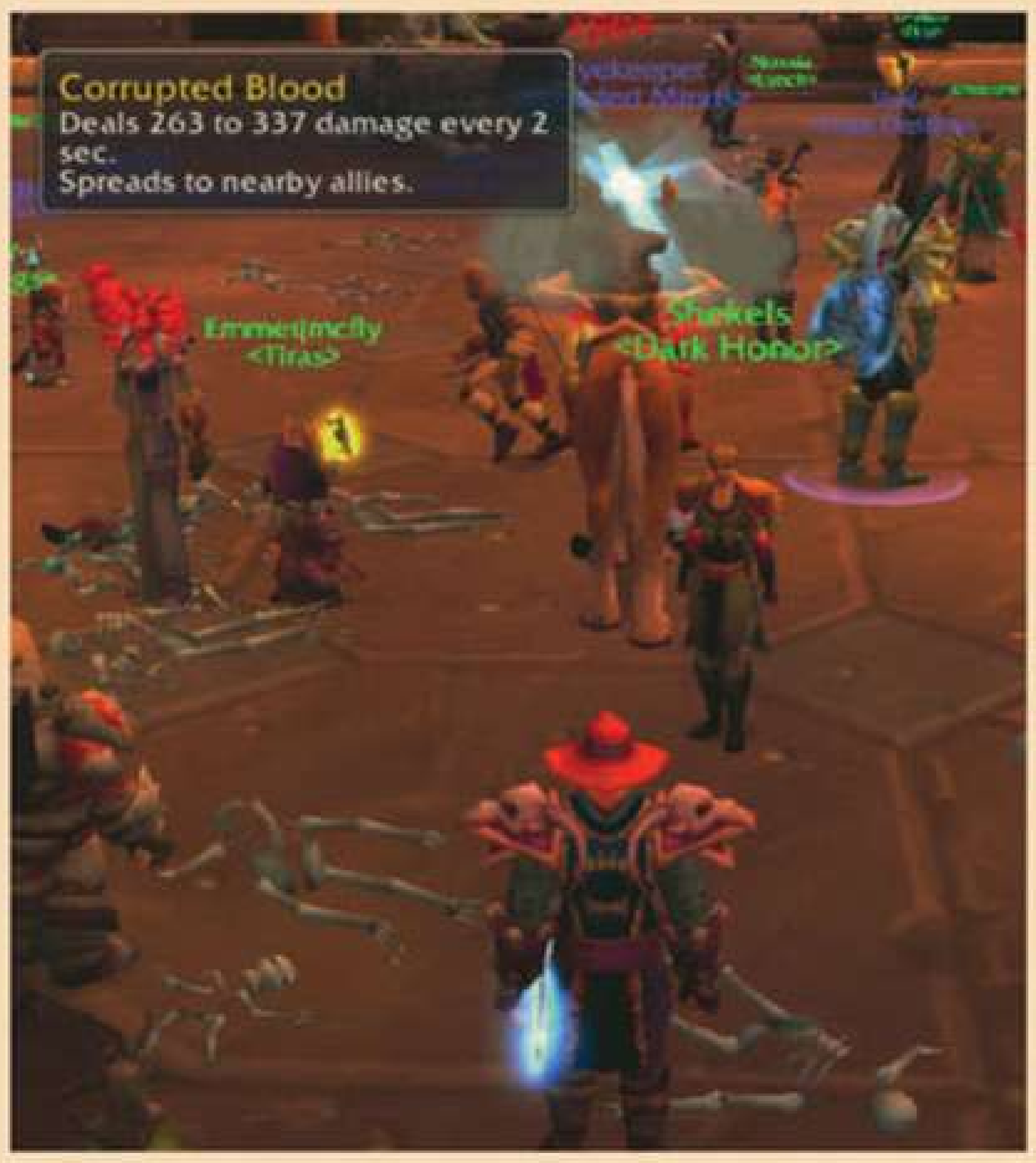
We're not too far off playing such a game. In the online world of *TERA*, each province is ruled by a player ▶

PLAYING SCIENCE

How researchers are harnessing the power of games

HEALTH

Deep in the jungles of *World Of Warcraft*, there lurks a giant troll, and this troll carries a disease. Players who fight the beast can receive an attack that inflicts damage on them every few seconds, persisting over time. The effect can also leap from player to player: if your character is near an infected character, you also become a victim – you 'catch' the disease. The game developers intended for the illness, called Corrupted Blood, to expire when players left that particular area of jungle, but in 2005 – due to a software bug – some players carried the disease out into the wider world. It put the entire population of the game at risk of infection. This unintended plague garnered the interest of epidemiologists, who saw it as a model of real-world infection. For instance, disease travels along social vectors, and this holds true in massive multiplayer games, with diseases passing to friends and co-workers first.

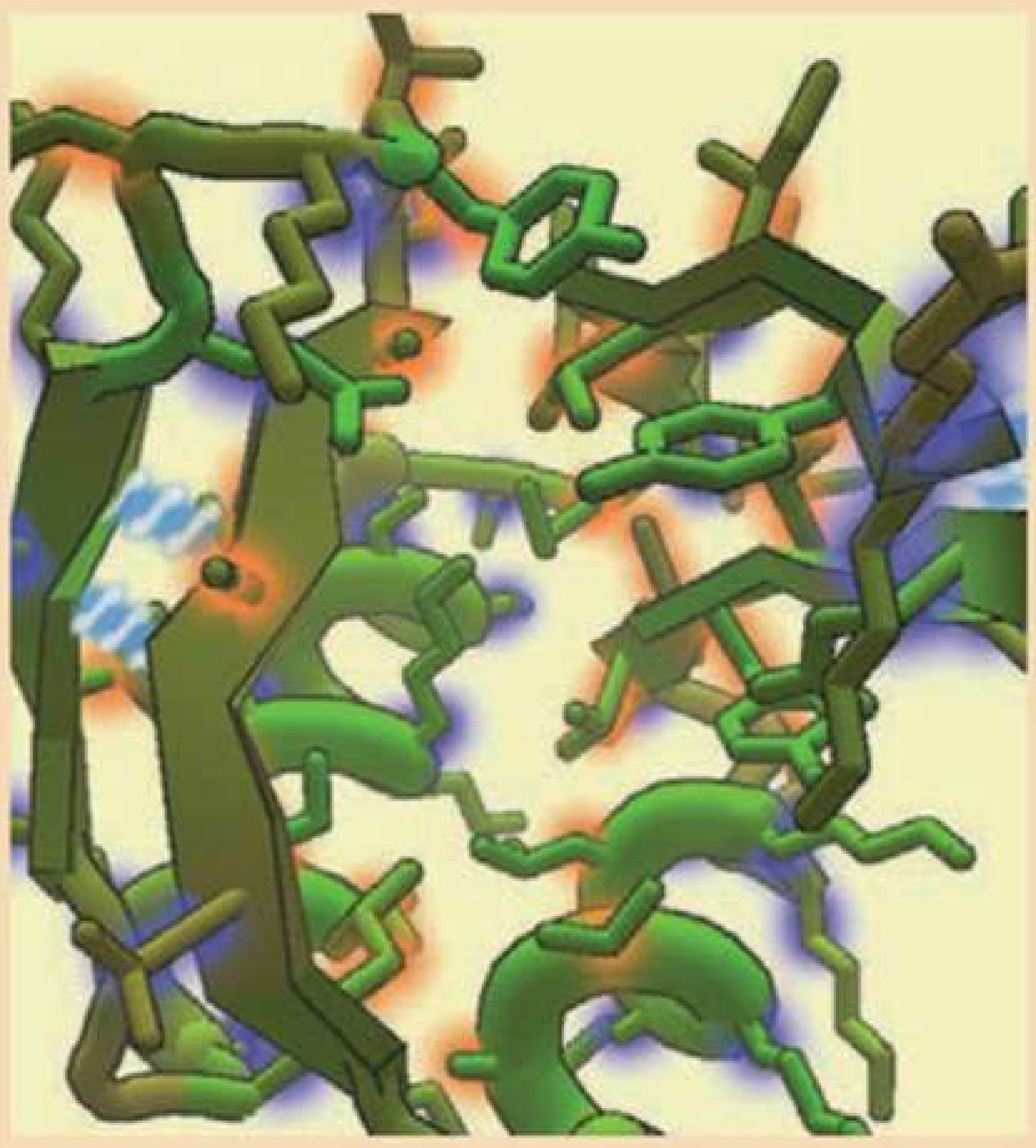

Corrupted Blood
Deals 263 to 337 damage every 2 sec.
Spreads to nearby allies.
Emmetmefly <Tiras>
Shekels <Dark Honor>

ECONOMICS

In 2008, the world wondered how a system carefully observed and administered by smart people could suddenly collapse in a matter of weeks. Whereas a biologist can put societies of germs in separate petri dishes and do tests to see what happens, macroeconomists say they can't experiment on the economy. Or can they? A study of the multiplayer game *EverQuest* revealed that economic factors like gross domestic product, inflation and money supply behaved in the game much as they do in the real world. In principle then, it should be possible to build virtual versions of real-world economies. If traders want to play around with mortgage credit swaps, they can do so in virtual form first. That way we could learn the financial system's vulnerabilities before letting that type of asset loose in the real world.

MOLECULAR BIOLOGY

Some problems are very hard for computers to solve. Take the folding of proteins, which can bend and twist in different ways to change how they interact with other molecules. One way scientists have found useful new folds is through a computer game. Players of *Foldit* can bend proteins to find good twists. A certain bend can break a protein or waste energy in a chemical bond – some bends work very well, others are poor. The human brain is more adept at this task as a computer would take a long time to crunch through possible protein bends and has no sixth sense for determining where progress has been made. Hundreds of thousands played *Foldit*, and they've found a number of great folds that would have taken scientists and their computers decades to discover. Finding out how proteins work could help fight diseases such as cancer, HIV and malaria.



▶ who gets to choose the terms of succession. You may decide to have a democracy – leaving you open to being voted out of office by other players – or an autocracy that can be toppled by being bested in individual combat. A game about society can therefore teach real lessons about co-operation, civic duty and non-violence.

Another possibility is a game that inspires young people to become heroes in reality. Pop stars, sportsmen and other glamorous professions get all the press, yet the choices made by medics in charitable foundations such as Doctors Without Borders would not only make for exciting gameplay, they'd also be fraught with tension and significance. Imagine being a doctor in a war zone, surrounded by the sick and dying: how do you prioritise who most urgently needs emergency aid?

The educational game *Food Force*, in which you help fight starvation, is a step in this direction. Developed by the UN World Food Programme, the game enables children to complete virtual missions such as air-dropping food via helicopter, rebuilding villages, and negotiating with warlords.

The word 'gamification' suggests that you can take anything and easily turn it into a game. Ideas for games that could help save the world aren't in short supply – it's implementing those ideas that needs more thought. It's hard enough making people care about global warming. So how do you make them care enough to play a *game* on global warming?

At a time when the promise of games seems so great, it's important to recognise how little we understand about them. The science of psychology hasn't yet developed a 'theory of fun', let alone tested and refined it to the point where digital entertainment has obvious practical applications.

With further research into gaming's possibilities, coupled with improved technology, the future could be one in which we are able to fully harness the power of games for the benefit of society and the world as a whole. ■

Edward Castronova is professor of telecommunications and cognitive science at Indiana University

FIND OUT MORE

Grand Theft Childhood by Lawrence Kutner and Cheryl Olson (Simon & Schuster, 2008)

Reality is Broken by Jane McGonigal (Jonathan Cape, 2011)

In *TERA*, you can become a ruthless dictator or form a democracy

BRAIN BOOSTERS

Games have a positive effect on the mind and can improve mental health

Dr Carmen Russoniello, right, is trying to combat depression with games

The rise of smartphones and computers has made games easy to access, but this doesn't explain why they've become so popular – or why we find them fun to play. "We're trying to tease that out scientifically," says Dr Carmen Russoniello, director of the psychophysiology lab at East Carolina University, who studies the effects of games on the body and brain.

Russoniello started studying games after being approached by the developer PopCap. Its user surveys suggested that people found their games relaxing, which could reveal the scientific secrets behind making a successful game. To investigate this, Russoniello measured various things: alpha brain waves (via EEG readings) to determine mood; heart-rate variability to assess stress; and detecting the flow of amylase in saliva to study relaxation. The data revealed that, compared to a control group that browsed websites, people who had played a game were more relaxed and less stressed.

According to the World Health Organisation, 121 million people suffer from depression, and by 2020 it will be the second highest cause of a shortened life span globally (after heart disease). Russoniello's results open up the possibility of using games to help treat people when anti-depressants don't work or need to be supplemented.

In a follow-up clinical study, Russoniello split a group of depressed people into two groups: the control group read reassuring and practical information about depression on the US National Institutes of Health website, while the other group were given a 'prescription' to play one of PopCap's puzzle games at least three times a week for 30 minutes. The games not only reduced depression in the short term, they also kept it down when patients had a check-up a month later. Another advantage of games is that, unlike taking drugs – which can have side-effects, there's high 'compliance' for the course of treatment – people want to play their prescribed game.

Casual games could also help improve the mental health of ordinary people, enabling us to manipulate our mood when desired, something we already do with music. "In the future, I see people going into software stores online and choosing games that have specific effects," says Russoniello.

CARMEN RUSSONIELLO/US ARMY, GAMESPRESS

3 issues for £5*

when you subscribe to *Sky at Night Magazine* by Direct Debit*

BBC
BEHIND THE SCENES AT THE VERY LARGE TELESCOPE
THE BIGGEST NAME IN ASTRONOMY
Sky at Night
ADVENTURES IN ASTRONOMY
We take you to 18 of the planet's greatest dark-sky destinations
STARGAZING SKILLS: FIND YOUR AIM ON THE STARS
RED PLANET SPECIAL
UNMISSABLE MARS
REVIEWED: PORTABLE ASTRO-TRACKING MOUNTS
TAKE THE SPRING SKY TOUR
See 21 stunning deep-sky objects before summer arrives
PLUS 55 years of The Sky at Night
APOLLO 16 SPECIAL
IMAGE PROCESSING

As well as complementing the television programme with in-depth features on the latest areas of cosmological research, *Sky at Night Magazine* is your practical guide to astronomy, featuring star charts, observing tutorials and in-depth equipment reviews. Whatever your level of knowledge, you'll find something to enjoy in the night sky.

Your special subscription offer

- ▶ **3 issues for just £5***
- ▶ Continue to **save 25%** after your trial period
- ▶ **Exclusive CD-ROM** with every issue
- ▶ Receive **free UK delivery** direct to your door

SUBSCRIBE ONLINE

www.buysubscriptions.com/skyatnight

☎ **CALL US ON 0844 844 0254**†

PLEASE QUOTE FOHA712

†Calls to this number from a BT landline will cost no more than 5p per minute. Calls from mobiles and other providers may vary. Lines are open 8am-8pm weekdays & 9am-1pm Saturday.

*Offer ends 27 June 2012. 3 issues for £5 offer only available to UK residents paying by Direct Debit. After your first 3 issues your subscription will continue at £19.99 every 6 issues, saving 25% on the shop price. If you cancel within 2 weeks of receiving your 2nd issue, you'll pay no more than £5. Your subscription will start with the next available issue.

Q&A

Your questions answered

How many atoms thick is cling film? p72
Do black holes spin around other bodies? p73
What's the highest skyscrapers will go in the future? p75
How do waterless toilets work? p79

Why do some fish swim in schools and others alone?

MEL RIDER, CUMBRIA

Schooling is a tactic that has several advantages. It reduces vulnerability to predators, improves access to breeding partners and lowers the hydrodynamic drag when swimming at speed. It can also make it easier to find food, but not under all circumstances, and this is the primary reason that some fish do not school.

When a fish feeds on large numbers of highly mobile prey much smaller than itself, swimming in a school makes hunting easier. This is because prey that jumps out of the way of a neighbour's mouth might land itself within striking distance. But if the food source is solitary or well hidden, or if the fish feeds on plants, then other fish just represent more competition for a limited resource, and it's better off feeding alone. **LV**

JURGEN FREUND/NATUREPL.COM, THINKSTOCK, SCIENCE PHOTO LIBRARY GETTY, SUPERSTOCK

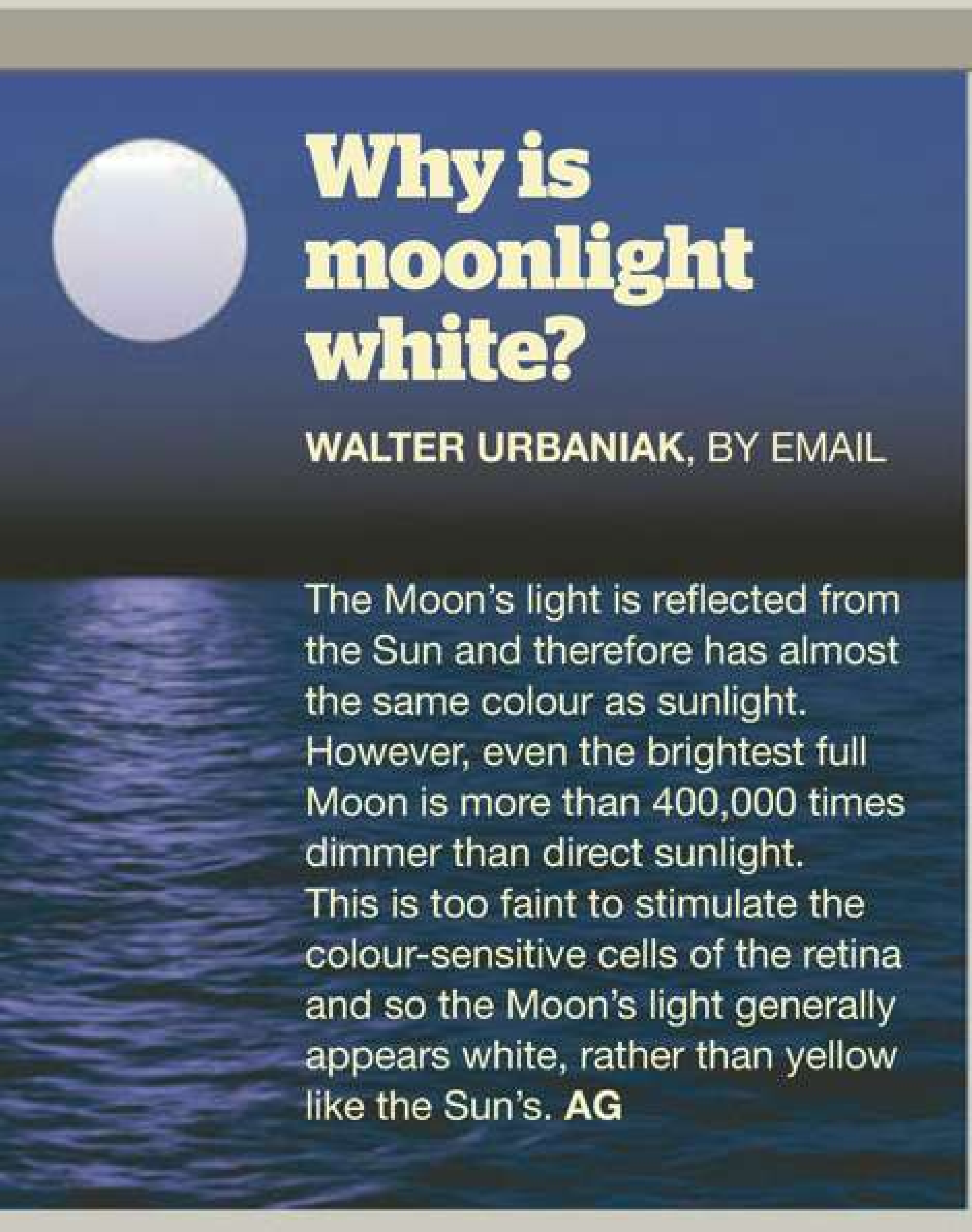
1,000mph

The speed of a car being developed by a British team. Called the Bloodhound SSC, it will attempt the land speed record.

Send us your questions

questions@sciencefocus.com

Focus magazine Q&A,
Tower House, Fairfax Street,
Bristol, BS1 3BN



Why is moonlight white?

WALTER URBANIAK, BY EMAIL

The Moon's light is reflected from the Sun and therefore has almost the same colour as sunlight. However, even the brightest full Moon is more than 400,000 times dimmer than direct sunlight. This is too faint to stimulate the colour-sensitive cells of the retina and so the Moon's light generally appears white, rather than yellow like the Sun's. **AG**

Will teleportation ever be possible?

JACK WEBB, ESSEX

We can already use 3D scanners to record the shape of something, transmit the data across a network and have a 3D printer build a copy of it at the other end. For simple plastic models, that's a kind of teleportation. The resolution of the scanner and the materials used by the printer will doubtless improve over time, perhaps to the point where it will be possible to 'teleport' quite complex objects.

But the *Star Trek*-style transporter is almost certainly impossible. Imagine 'printing' a human. Simply positioning the same atoms in the right point in space isn't enough. The atoms need to be joined into the right molecules; the molecules need to be arranged into cells. The atomic and molecular bonds all need to happen in a certain sequence, mediated by enzyme action and built up gradually over time. Doing this fast enough to count as teleportation is out of the question for any living tissue. **LV**

Och aye the noo!

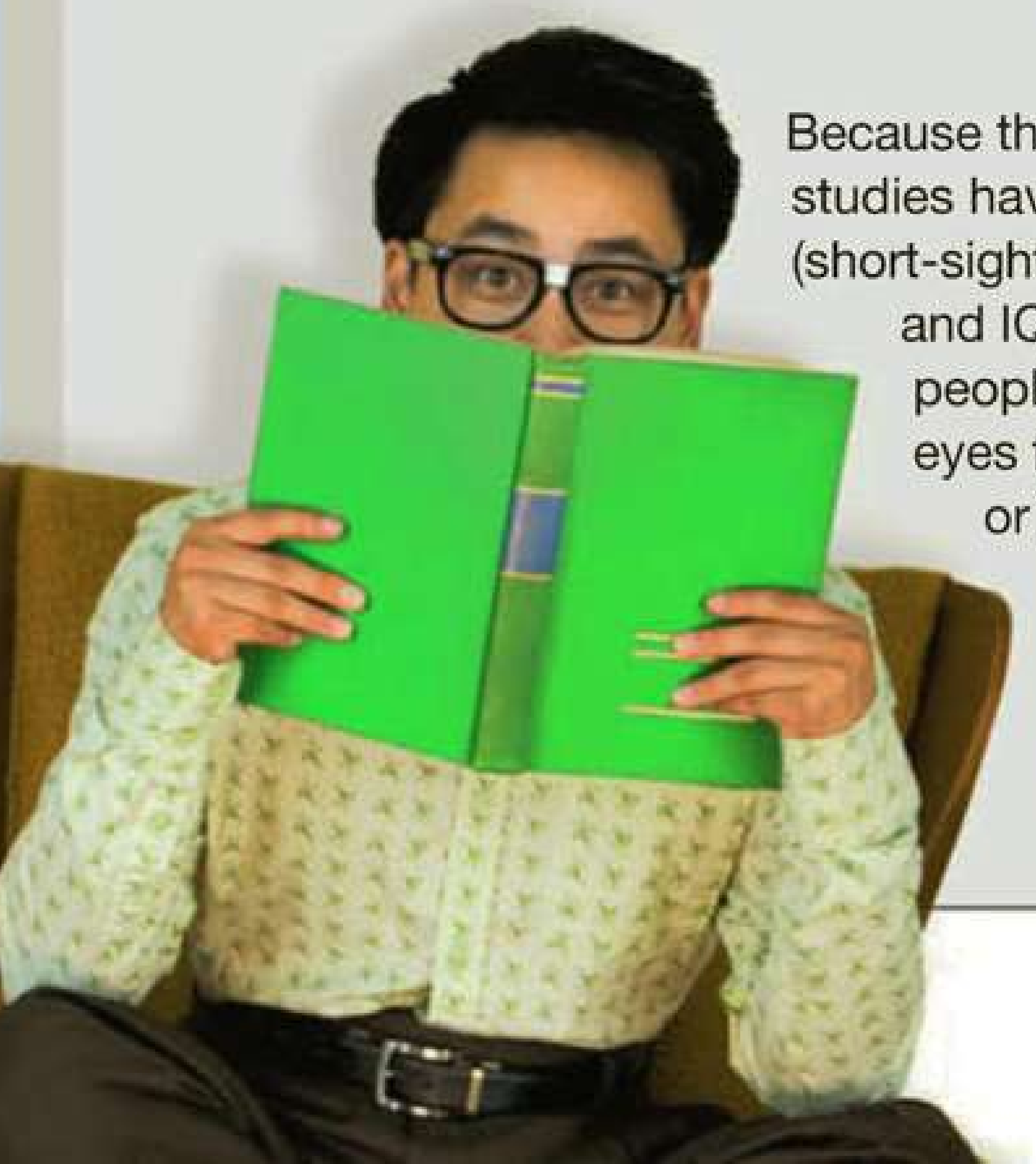
At what age are accents determined?

PETER YOUNG, HEREFORD

Very young – from the moment toddlers begin to speak, they copy the sounds they hear. Up to the age of puberty children can pick up other accents easily, and immigrant children typically speak with less noticeably 'foreign' accents than their parents. If by 'determined' you mean unable to be changed, then that is quite variable but generally accents remain malleable until a person's early twenties. That said, the Queen's accent has changed measurably during the years of her long reign! **SB**

Why do we associate glasses with intelligence?

JOANNA TAYLOR, BY EMAIL



Because there is a real correlation. Numerous studies have shown a link between myopia (short-sightedness) and both educational level and IQ. This may be because myopic people enjoy reading more, since their eyes focus better at short distances, or it may be that intelligent people tend to read more and this causes myopia. The evidence for either hypothesis is currently inconclusive. **LV**

The experts

SUSAN BLACKMORE
Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*

DR ALASTAIR GUNN
Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics

ROBERT MATTHEWS
After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University

GARETH MITCHELL
Starting out as a broadcast engineer, Gareth now writes and presents *Digital Planet* on the BBC World Service

LUIS VILLAZON
Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach the Ground*

Do chess computers always beat humans now?

BRIAN CRAWLEY, NOTTINGHAM

In May 1997, IBM's Deep Blue computer beat chess champion Garry Kasparov, becoming the first machine to defeat the best human player across an entire six-game match. Capable of calculating 200 million possible moves per second, Deep Blue overcame Kasparov with brute computing strength. Deep Blue was dismantled after the match, but some computers remain unbeaten. Although discontinued, the Hydra supercomputer saw off British Grandmaster Michael Adams (pictured) in 2005. Adams was only able to score a single draw in a whole match. Hydra was capable of processing 200 million possible moves a second and could figure out what was going to happen 40 moves ahead! **GM**

How does soap work?

RICHARD SOMERVILLE, NORTHAMPTONSHIRE

The structure of soap molecules enables them to remove dirt with ease. They consist of a hydrocarbon chain, with a sodium or potassium atom at the end. The hydrocarbon end is attracted to oil and repels water, whereas the other end attracts water. When you wash your hands, oily dirt particles are surrounded by soap molecules with their water-loving heads facing outwards. This breaks up the dirt and lets it wash away in the water. **LV**

87 **is the average age that British men and women will live to by 2030, according to the Office for National Statistics.**

How do deep-sea creatures survive huge pressure changes?

NICK CARTER, FAREHAM

Most deep sea creatures stay at the same depth, so the pressure doesn't change. Sperm whales, however, can dive from the surface to depths of 3km. They have a flexible rib cage to allow their lungs to collapse as they descend, limiting the amount of nitrogen their lungs absorb. But even so, there is some evidence that they can suffer pitting in their bones from decompression sickness if they surface too rapidly. **LV**

How many atoms thick is cling film?

DAVID PAYLOR CENG, BY EMAIL

According to the technical data supplied for Saran Wrap (a popular brand in the US), cling film is 12.7 microns thick (0.0127mm). The two most common materials used are polyvinylidene chloride (PVdC) and low density polyethylene (LDPE). Taking PVdC as an example, the width of the chlorine-carbon-chlorine bond in a PVdC molecule is about 0.28nm. Assuming the polymer molecules are packed tightly together to form a sheet of cling film, this gives a thickness in the region of 140,000 atoms. **LV**

GETTY, THINKSTOCK X8, GETTY, DAVID SHALE/NATUREPL.COM

Does tapping the can stop a drink fizzing over when you open it?

KEITH DUNCAN, EDINBURGH

When you shake a can, some carbon dioxide comes out of solution and bubbles form on the inside. Opening it causes a sudden drop in pressure that makes the bubbles grow much larger. It also triggers new bubbles to form, as carbon dioxide comes out of the solution around existing bubbles, points known as nucleation sites. The bubbles rise suddenly to the surface, and the whole frothy mess explodes out of the top. Tapping the sides of the can before you open it might help to dislodge the bubbles, so the gas is all at the top of the can and there are fewer nucleation sites. But it's only partially effective. Leaving the can to stand for a minute works better. **LV**

Is the temperature of the Universe increasing?

IAN HUTT, BUCKINGHAMSHIRE, BY EMAIL

With all those stars pouring their heat into space for billions of years, you'd think the Universe must have warmed up a little by now. But that overlooks the fact that the Universe is also expanding, thus spreading the heat of the stars ever more thinly. As a result, the prime source of cosmic heat is that left over from the Big Bang 14 billion years ago – and that's slowly petering out.

In 2008, astronomers used one of the world's largest telescopes, based in Chile, to detect molecules of carbon monoxide in a galaxy 11 billion light-years away. The behaviour of these molecules reveals the temperature of space around them, which turned out to be –264°C – 7°C warmer than the Universe is today. **RM**

QUICKFIRE

What causes period pains?

TESSA BEECHING, BRISTOL

Contractions of the uterus cause this type of pain. Waves of contraction happen continuously but they are stronger during menstruation, when they throw off the lining of the uterus so that a new one can grow ready for the next menstrual cycle. They reduce the blood supply to the uterus and the resulting lack of oxygen causes pain. The release of hormone-like prostaglandins increases contractions and may also directly lead to pain. **SB**

Do black holes spin around other bodies?

DAVID ROBINSON, BY EMAIL

Black holes are often found in association with other objects. For example, 'X-ray binaries' can contain a black hole in orbit around a star. Although we can never see a black hole directly, we can detect it due to its effect on nearby objects. **AG**

How much food production is now genetically modified?

ROBERT PERRY, BY EMAIL

Concern about the potential ecological and health effects of 'GM' food sparked a furore during the 1990s. But since then, the technique has been adopted ever more widely. GM crop production has soared 100-fold since the mid-1990s, with soybean and maize heading the list of GM foods – over three-quarters of all soybean and a quarter of all maize grown is GM. The US and South America are the principal producers, while Europe still grows virtually none.

TOP TEN
BODILY MEASUREMENTS

300,000
000,000
new cells are created in your body every day

600,000
particles of skin your body sheds every hour

500,000
sweat glands in your feet

60,000
miles of blood vessels

50,000
different smells that your nose can remember

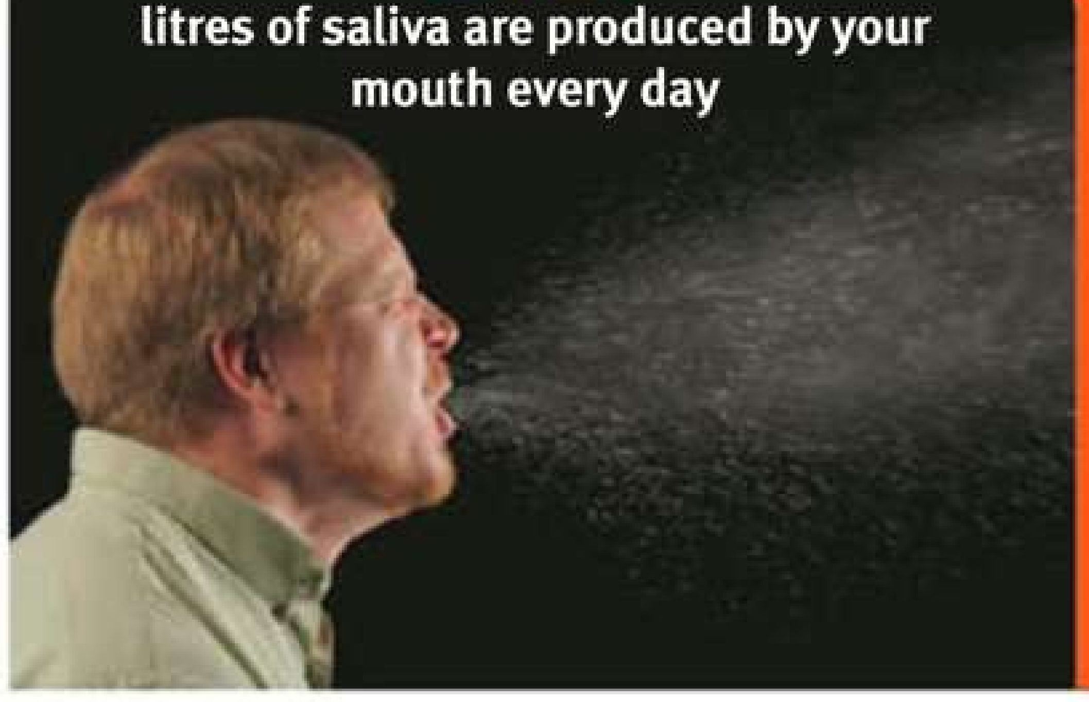
500
the number of functions performed by your liver

250
miles per hour – the speed at which nerve impulses travel

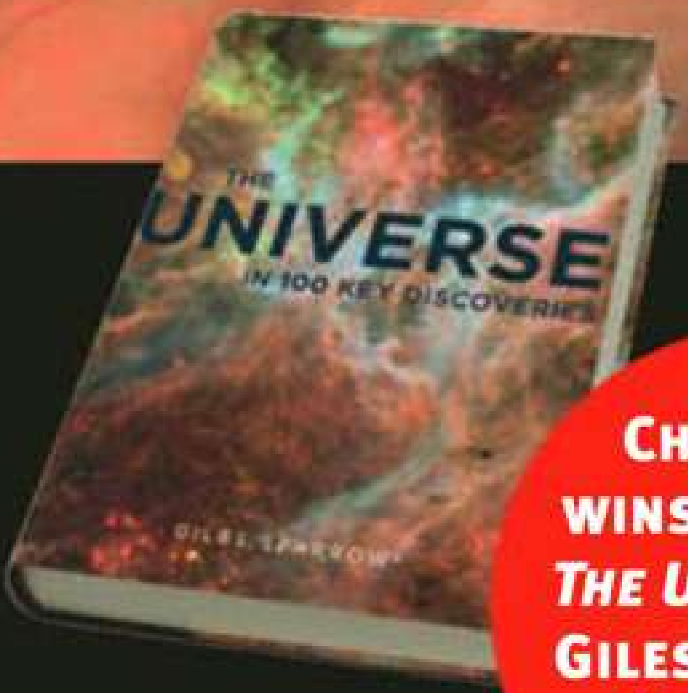
200
muscles are used to take one step

100
mph – the speed your sneezes travel

1-2
litres of saliva are produced by your mouth every day



SUPERSTOCK, SCIENCE PHOTO LIBRARY, GETTY, PRESS ASSOCIATION



QUESTION OF THE MONTH

CHARLOTTE WINS A COPY OF *THE UNIVERSE* BY GILES SPARROW (QUERCUS, £19.99)

Is the brain of a genius heavier than an average brain?

CHARLOTTE HEPPLEWHITE, BASINGSTOKE, BY EMAIL

Possibly, yes, but size alone cannot explain why some of us are regarded as geniuses. Some large-brained animals such as dolphins and whales are very intelligent, but so are crows with their tiny brains.

The brains of geniuses such as Albert Einstein have been measured, but no relationship with size or weight was found. One study revealed that Einstein had more glial cells than average. These support and protect neurons, suggesting that his brain demanded more energy.

Other studies show that geniuses have more long-range neural connections that reach from one area of the brain to another. Yet no single feature explains their exceptional abilities. Persistence, hard work and determination may be just as important, and they do not require an especially heavy brain. **SB**

Why is water wet?

JOSIE SECO, LONDON

Partly it's by definition, since 'wet' is normally taken to mean 'coated with a layer of water'. But scientifically, wetting also refers to the ability of a liquid to stick to a solid surface. Liquid mercury isn't very wet because it rolls straight off most surfaces. That's because its atoms don't give up their outer electrons easily and so it doesn't form electrostatic bonds with other surfaces. Water molecules are polar – they have a negatively charged oxygen atom and two positively charged hydrogen atoms, sticking out like Mickey Mouse ears. These electrical charges allow water molecules to form weak electrostatic bonds with lots of different substances.

The wettest liquid of all is liquid helium. Below 2.18 Kelvin (-270.97°C), helium becomes a superfluid. This is a very strange quantum state of matter that only happens at extremely low temperatures and causes it to lose all friction and viscosity. Superfluid helium will creep up the sides of a cup and over the top, until it has all escaped. **LV**

What's the highest skyscrapers will go in the future?

TOM RAYLEY, SALFORD, BY EMAIL

The current tallest building in the world is the Burj Khalifa in Dubai (pictured). At 828m, it is nearly three times higher than the Shard London Bridge. The 443m Empire State Building was once the world's tallest, but is only about half the height of Burj Khalifa. It seems we can just keep going taller, especially as exotic, super-strong lightweight materials like nano-enhanced concrete become more affordable.

But one limit is a building's footprint. Already, the bases of skyscrapers take up nearly as much space as a New York City block. The other issue is elevators. The fastest can manage 17m per second. Non-stop, that's nearly a minute to scale a 1,000m tower. To reach the top of a 4km-high building would therefore take a while! But architects at the Japanese company Taisei have conceived of just such a tall building. The X-Seed 4000 is simply a proof of principle for now. It's unlikely to be built, requiring a 6km-wide base located in the sea. **GM**

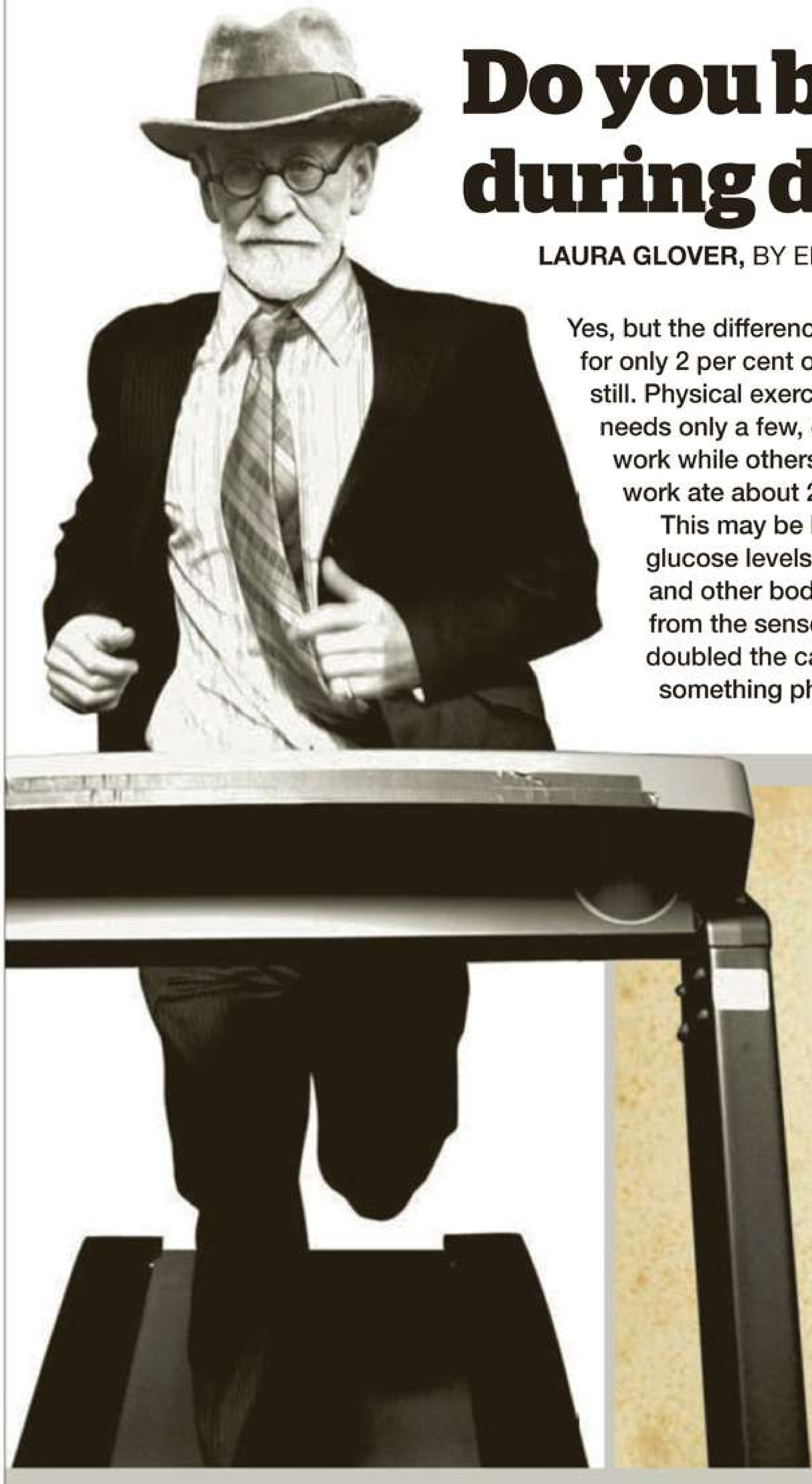
120,000ft

The height at which Felix Baumgartner is planning to skydive from this summer. Setting a new world record, he will dive from the edge of space in a pressurised suit.

Why are cowpats sloppier than other herbivore droppings?

GRAHAM BARNES, SUSSEX

Cows are ruminants. This means that their food is chewed twice: once when they graze, and then a second time when partially digested grass (cud) is passed back up to the mouth for another going-over. This, plus the four-chambered arrangement of their stomachs, makes ruminant digestion about 70 per cent more efficient than other herbivores, such as horses. So the poop that finally emerges is more completely broken down and has none of the leftover plant fibres that give horse droppings their structure. Cows fed on silage, which is already partly fermented, have even runnier manure. **LV**

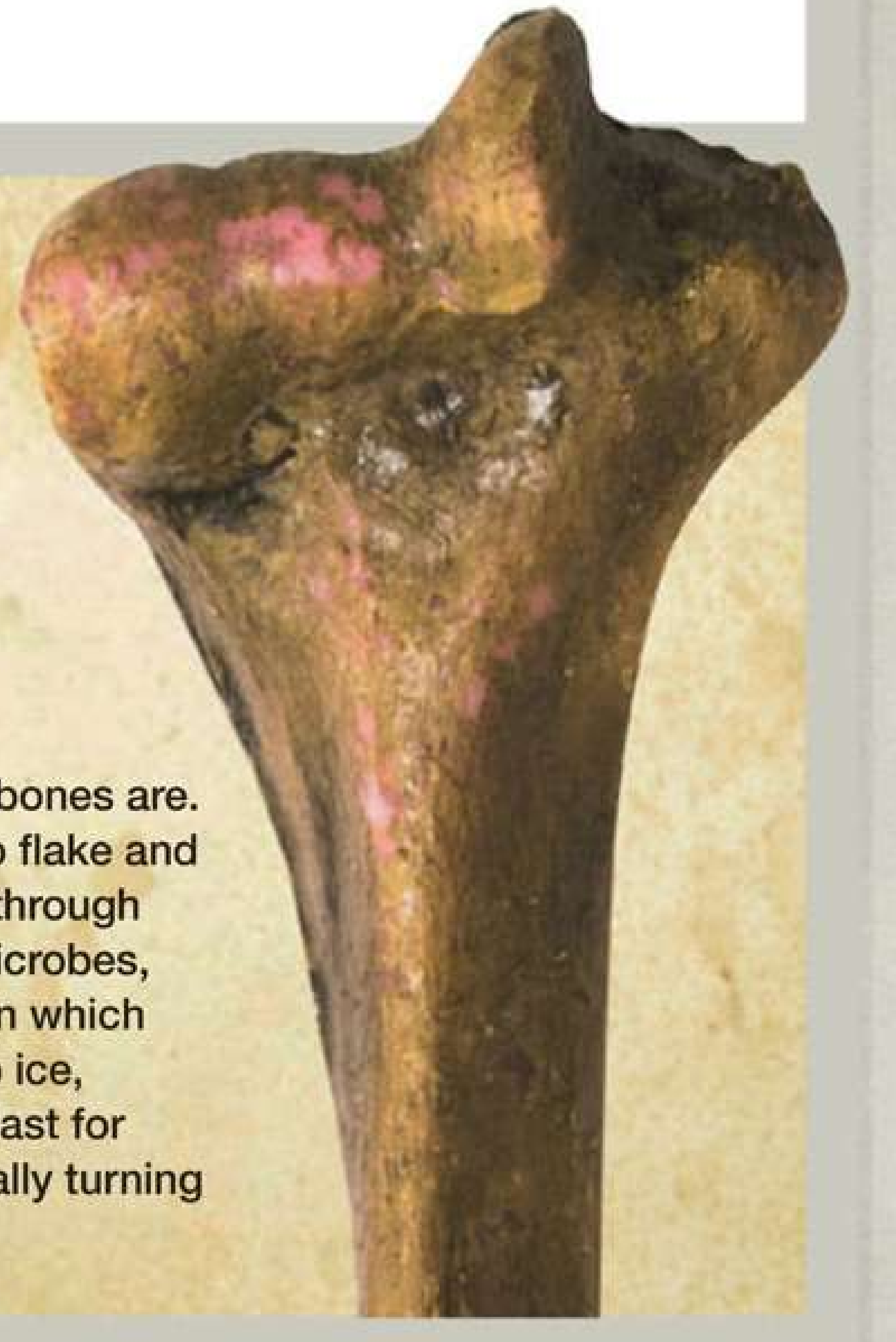


Do you burn more calories during deep thought?

LAURA GLOVER, BY EMAIL

Yes, but the difference is tiny. The common claim that the brain uses 20 per cent of the body's energy for only 2 per cent of body weight, makes it sound very demanding. But this only applies if you keep still. Physical exercise quickly demands lots more calories to power the muscles, while deep thought needs only a few, even if it makes you hungry. In one study some students did intense computer work while others relaxed. There was almost no difference in energy used, but those doing mental work ate about 200 more calories afterwards.

This may be because the brain uses glucose for fuel, and intense thought lowers blood glucose levels. Another reason is that the brain never stops controlling breathing, digestion and other bodily functions. At night it is busy dreaming and by day processing information from the senses. All this takes less than one calorie a minute. So even if deep thought doubled the calories used, this would be a small increase compared with getting up and doing something physical. **SB**



How long do human bones take to decompose?

RON BARNES, KINGS LYNN

The answer depends crucially on where the bones are. If exposed to the elements, they will begin to flake and crack apart after a few years. This happens through a combination of attack from scavengers, microbes, ultraviolet light and the 'freeze-thaw' cycle, in which water penetrates small cracks and turns into ice, breaking the bone. But if buried, bones can last for millennia, with those left in sediment eventually turning into fossils. **RM**

What causes left-handedness?

OLIVER STEWART, COBHAM

Being left-handed is the result of genes and environment. About 50 per cent more males than females are left-handed and 17 per cent of twins are, compared with about 10 per cent in general. The 'vanishing twin' hypothesis suggests that left-handers were originally a twin, but the right-handed foetus failed to develop.

Brain dominance also appears to play a part. Most people are right-handed and have language controlled by the left hemisphere, and most left-handers are the opposite. However, some left-handers have language processing in the left hemisphere, or in both.

The genetic basis for left-handedness is complicated. Even if both parents are left-handed there is only a 26 per cent chance of their child being left-handed. Possessing the 'LRRTM1' gene increases the chances, but only if it is inherited from the father.

But whether you become left-handed or not is also dependent on development. It may be influenced by levels of testosterone or oestrogen during pregnancy; early experience with holding and throwing things can affect later hand use. And finally, damage to the right hand can make people left-handed. SB

DID YOU KNOW?

The tallest living tree was measured in August 2006 at the Redwood National Park in California. A coast redwood (*Sequoia sempervirens*), it reached a grand height of 115.4m (379ft 1in). Dubbed Hyperion, it's over twice the height of the 46m-tall Statue of Liberty.

PRESS ASSOCIATION, GETTY, ALAMY X2, ILLUSTRATION BY ACUTEGRAPHICS

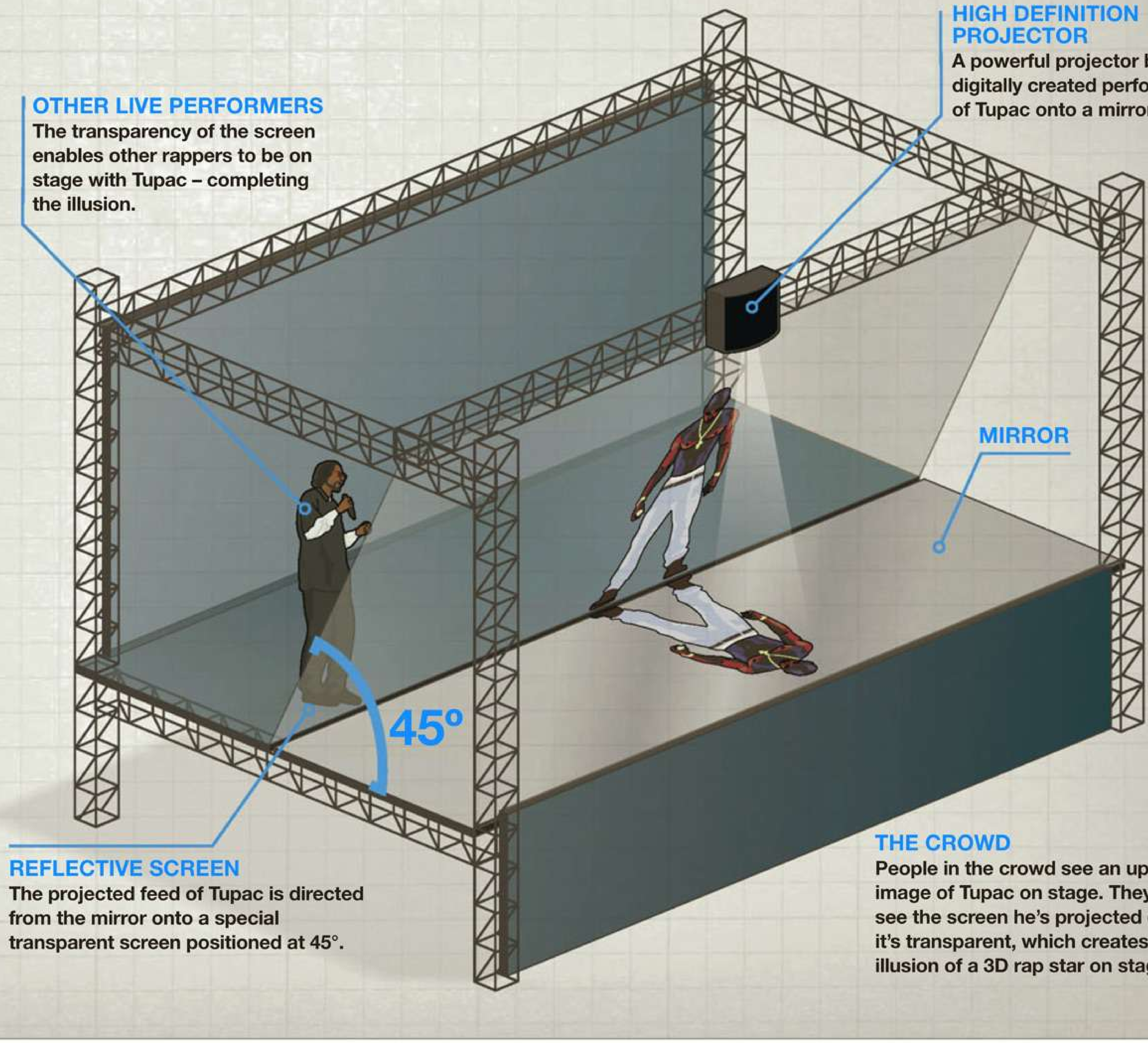
How was rapper Tupac resurrected?

Back in April, hip-hop fans at a music festival in Coachella, California, couldn't believe their eyes. Sixteen years after his death, the rap icon Tupac Shakur appeared on stage performing alongside Snoop Dogg. What people were really looking at was a trick of light – an updated version of a 19th century illusion known as Pepper's Ghost.

AV Concepts used projection technology developed by Musion Systems Ltd to 'resurrect' Tupac. A high-definition projector positioned above the stage beamed digitally created footage of the legendary rap artist down onto a mirror. This reflected the feed onto a transparent screen positioned at a 45° angle, so that the image is upright when it's reflected on to the on-stage screen. Made from a special plastic substrate, the screen acts like a mirror, but without a silvered back so that it's see-through. The audience can't see the screen at all because it's tensioned like the skin of a drum to remove any telltale wrinkles, and the transparency enables other live performers to be on stage behind the projected image.

While the effect has been called a hologram, it's actually a 2D projection; a hologram can be viewed from multiple angles. The image looks 3D in the minds of the audience because they can't see the screen it's projected onto and are positioned directly in front of it. The high clarity of the final image has only been made possible due to advances in the brightness and definition offered by projectors. The projectors used for this kind of performance deliver a high-definition pixel count of 1,920x1,080 at a brightness of 20,000 lumens – a home projector typically delivers under 3,000 lumens.

The technology can also be used for live telepresence communication over a high-speed internet connection. This would enable you to appear at a business meeting as a 3D projection, for instance. As for the world of entertainment, there are plans to take the Tupac performance on tour.



HIGH DEFINITION PROJECTOR
A powerful projector beams a digitally created performance of Tupac onto a mirror.

OTHER LIVE PERFORMERS
The transparency of the screen enables other rappers to be on stage with Tupac – completing the illusion.

REFLECTIVE SCREEN
The projected feed of Tupac is directed from the mirror onto a special transparent screen positioned at 45°.

THE CROWD
People in the crowd see an upright image of Tupac on stage. They can't see the screen he's projected onto as it's transparent, which creates the illusion of a 3D rap star on stage.

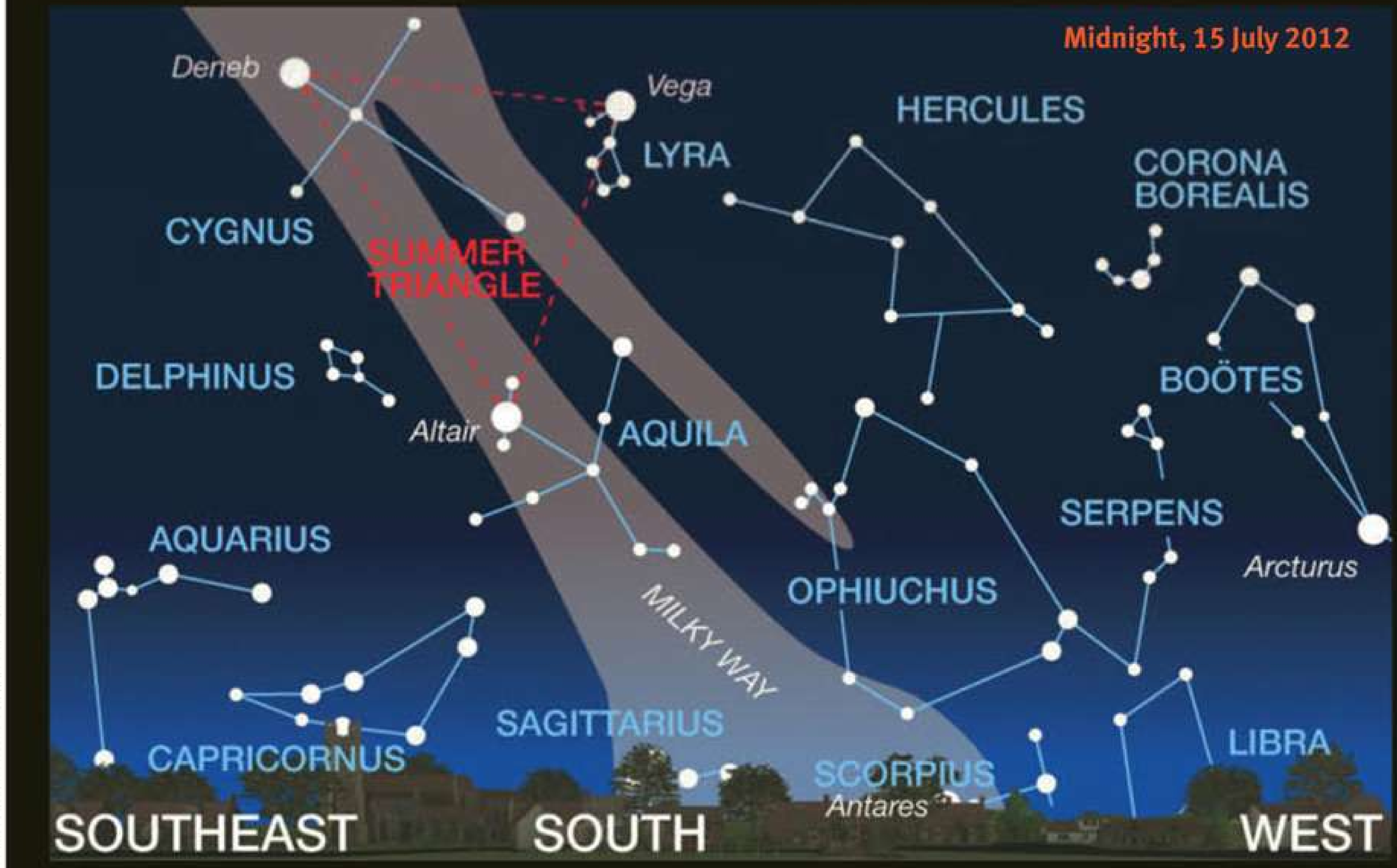
How close are we to finding life on another planet?

ANDREW MALDOON, LONDON

Most scientists believe life is unlikely to be found elsewhere in the Solar System. Although there are tantalising hints of 'biochemistry' on Mars, as well as conditions potentially conducive to life on some of Jupiter and Saturn's moons, these would probably require human exploration to settle the debate. And this isn't going to happen any time soon!

The best chance of finding extraterrestrial life lies in closely scrutinising planets discovered orbiting other nearby stars, the so-called 'exoplanets'. We know of over a thousand of these and many orbit their stars in the 'habitable zone', where liquid water may exist. Studying the atmospheres of these Earth-like planets could reveal chemical signatures indicative of life, but there are currently no instruments capable of this demanding task. So, although science has made great progress on this issue in recent decades, it is impossible to say yet whether we are any nearer to answering this most fundamental of questions. **AG**

Skywatching with astronomy gurus Heather Couper and Nigel Henbest



Use the Summer Triangle, high in the south, as your guide to the fainter constellations of the July sky, enlivened by the brilliant star Arcturus in the west and the star Antares hugging the southern horizon.

What can I see in July?

● All night, all month, high in the south

The 'Summer Triangle' of bright stars Vega, Deneb and Altair dominates the skies. Each is the 'lead star' in their own constellation: Vega in Lyra, Deneb in Cygnus, and Altair in Aquila. Vega is the most brilliant of the trio – a dazzling white star that scrambles to the overhead point in the heavens this month. It's surrounded by a disc of dust that might be forming planets and may already have hatched a world that's about the mass of Jupiter.

● 15 July, north-east, 2.55 – 3.10am

The Moon passes over Jupiter in what's known as an occultation, with brilliant Venus below. A great sight to the naked eye, it's even better if you use a telescope; you'll get a great view of the gas giant as it disappears behind the limb of the Moon. It's best seen from the southeast.

Watch *The Sky At Night* on BBC One. Check radiotimes.com for details

BBC one

THINKSTOCK X3, ALAMY X3, ILLUSTRATION BY PAUL WOOTTON

How can a survey of just 1,000 people reflect a nation's views?

MARY DAWES, PETERSFIELD

Opinion polls are so commonplace that it's easy to forget the feat they claim to be able to perform: gauging, say, the popularity of President Obama by asking around 1,000 Americans. This amounts to just one in 300,000. The secret is to get hold of a random sample of people, but it's devilishly difficult to achieve.

By definition, a random sample has no inherent bias: it's as likely to pick young voters as old, rich as poor, right-wing as left-wing. The only factor then left to affect how many you get of each, is their relative proportions in the population. In other words, you'll have a small but representative sample of the whole nation.

Of course, there's still a price to be paid for not asking literally everyone their views, and that's a lack of precision in the final result. Statistical theory shows that a random sample of 1,000 people will give the relative proportion of, say, those keen on Obama to plus or minus around 3 per cent.

However, this will not be the case if the sample isn't random. For instance, it could come from an online poll, where the respondents themselves choose whether or not to take part. Such surveys can have severe biases, and must therefore be treated with caution. **RM**

How do waterless toilets work?

BEN SMITH, EXETER, BY EMAIL

One type funnels waste from the toilet bowl to a composting bin. The water content evaporates and is vented off. Microbes break the remainder down resulting in 'humanure' that is emptied every few months. There are also incinerating waterless loos. From the bowl, a corkscrew device feeds the waste into a chamber where the unmentionable is burned using propane or diesel. The result is sterile ash. **GM**

Will the internet ever be replaced?

RICHARD BATES, READING

The internet is a network of the world's computers using a standardised addressing protocol. This specifies how information 'packets' are sent and received. The physical infrastructure is constantly changing as new servers and fibre optics are replaced. As for the internet protocol, that is already changing from IPv4 to IPv6. The principal difference lies in the number of possible address locations. IPv6 offers a hundred million billion trillion addresses for each existing IPv4 one. **GM**

Could an animal be preserved in plastic, like a flower in a paperweight?

BARRY EADE, HAMPSHIRE

There's no reason why not. Beatles are often sold exactly like that and insects trapped in resin end up preserved in amber millions of years later. Larger animals need their internal organs removed first, as with taxidermy, and the epoxy resin needs to be applied in shallow layers to avoid the heat released during the process from damaging the specimen, but it's perfectly possible. **LV**

NEXTMONTH

Would it be possible to shut down the whole internet?

What size was the Universe at the point of the Big Bang?

Can you hypnotise a baby to sleep?

What is the maximum data capacity of fibre optic cables?

On sale: 28/06/12

If you can't wait until then, check out the Q&A archive

sciencefocus.com/qanda

BBC SCIENCE • TECHNOLOGY • FUTURE
FOCUS
SUMMER ISSUE
ON SALE 28/06/12

experiments that will change the world

From climate engineering to quantum computing, we reveal the science that will shape the future

The wristband that counts your calories

The world's deadliest volcanoes

Daredevil jump from the edge of space

The future of social networks

THINKSTOCK X2, RED BULL

COMPETITION TERMS AND CONDITIONS:

Competition Terms & Conditions Entrants must be UK residents (inc Channel Islands) aged 18 or over. Immediate Media employees are not eligible to enter. By entering participants agree to be bound by these terms and conditions and that their name and county may be released if they win. Only one entry permitted per person. No responsibility is accepted for lost, delayed, ineligible or fraudulent entries. The closing date and time are as shown on page 107. Entries received after that will not be considered. Entrants must supply their full name, address and daytime phone number. Immediate Media (publisher of *Focus* magazine) will only ever use personal details for the purposes of administering this competition unless you permit otherwise. Read more about the Immediate Privacy Policy at www.immediatemedia.co.uk/privacy-policy. The winning entrants will be the first correct entries drawn at random after the closing time. The prize and number of winners will be as shown on the Crossword page. The winners will be notified within 30 days of the closing date by post. Immediate Media's decision is final and no further correspondence relating to the competition will be entered into. The name and county of residence of the winners will be published in the magazine within three months of the closing date. If the winner cannot be contacted within one month of the closing date, Immediate Media reserves the right to offer the prize to a runner-up.

The **Guide**

Everything for the clued-up consumer

Don't miss

Mind power: the NeuroSky headset 86
Tune in to our test of digital radios 88
What it's like to be controlled by a robot? 93
Are big company buyouts killing the web? 97

CHELTENHAM **SCIENCE FESTIVAL**

The top show for curious minds is back and better than ever

From 12-17 June, the biggest names in science descend on the spa town of Cheltenham. Whether you'll be listening to the cosmic musings of Prof Brian Cox or watching a live brain scan, this year's show is sure to enthral. Here's our pick of events.

Graham Southorn, Editor

***Evolution: The Human Story,* 2-3pm, EDF Energy Arena, 13 June**

Get closer to our common ancestors with detailed replicas of our primitive relatives. Dr Alice Roberts is joined by the paleoartists behind the models to tell the story of our evolution from apes to modern human.

***Paradox: The Nine Greatest Enigmas in Science,* 4.30-5.30pm, EDF Energy Arena, 17 June**

BBC presenter and professor of physics Jim Al-Khalili explains the logic behind mind-warping paradoxes. He has a knack of making the bafflingly complex seem simple, but take some headache tablets just in case.

Andy Ridgway, Deputy Editor

***Going for Gold: Think Like a Winner*, Winton Crucible, 2-3pm, 14 June**

What makes scoring a penalty almost impossible when you're wearing an England football shirt? Hopefully sports psychologists David Lavallee, Marc Jones and Iain Greenlees will have some answers.

***Barry Marshall: The Human Guinea Pig,* Pillar Room, 8.30-9.30pm, 15 June**

Professor Barry Marshall was struggling to convince other medics that a bacterium, *Helicobacter pylori*, not stress – causes stomach ulcers. So he swallowed some. His resulting discovery won him a Nobel Prize. Here he talks about self-experimentation.

Daniel Bennett, Reviews Editor

***The Infinite Monkey Cage*, 4pm, EDF Energy Arena, 16 June**

BBC Radio 4's *The Infinite Monkey Cage* returns for a live recording. The chances of you getting a ticket are about as slim as neutrinos travelling faster than light – but if you can, you'll have ring-side seats to Brian Cox and Robin Ince's irreverent look at the world of science.

***Brain Scan Live: Lying and Deception*, 2-3.30pm, EDF Energy Arena, 17 June**

Some scientists believe that MRI scanners could be used as lie detectors. Psychologist Richard Wiseman, along with neuroscientists Mark Lythgoe and Derek Jones, test this theory live. You can also bring your own object to get it scanned in the Discover Zone.

Prices for individual events vary. For full details visit cheltenhamfestivals.com

Index

Objects of desire 83
The month's coolest new kit

First test 86
The NeuroSky headset

Tried & Tested 88
Multi-tasking digital radios

Tech Doc 93
What's it like to be a robot?

Games 94
Resident Evil 6: a first look

Web 97
Facebook's billion dollar takeover

Books 98
Essential reading for July

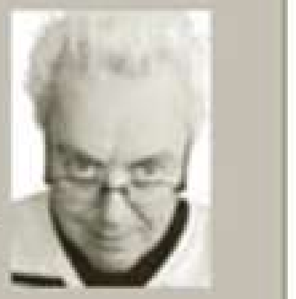
What's on 100
Events, exhibitions, talks and TV

The **Review** Squad

Daniel Bennett

Our reviews editor has been seemingly comatose at his desk, controlling his computer with the power of thought alone. He tests the NeuroSky headset on p86.

Russell Deeks



A music journalist for over 25 years, Russell was the perfect man to test the latest digital radios. Did they delight his finely-tuned ears? Find out on p88.

Jane Douglas

A section editor at Gamespot UK, Jane goes back to gaming's horror roots with *Resident Evil 6* and reveals how games are the perfect medium for sci-fi on p94.

Bill Thompson

The most important man on the web bar Justin Bieber, technology critic Bill looks at how company buyouts from the likes of Facebook are stifling the net on p97.

Timandra Harkness

Journalist Timandra is a human sponge when it comes to science programming – she gives her round-up of the best shows on TV and radio on p102.

ANTJE M POHSEGGER, BBC X3

TAKE YOUR WEBSITE TO NEW HEIGHTS WITH

THE HOSTING EXPRESS

WELCOME ABOARD

We're flying high with 3 million registered domains and 1.7 million websites. So join us and let your website take off with a first class web host.

DOMAINS *from £3.49 pa*

VPS *from £14.99 pm*

WEBSITE BUILDER *from £4.99 pm*

PERSONALISED EMAIL *from 99p pm*

GET ON-BOARD WITH...

"The UK's largest domain registrar!"

VISIT US TODAY 123-reg.co.uk

* Prices exclude VAT, Terms & Conditions apply.

THE SMARTPHONE EVOLVED

Samsung's new Galaxy graduates...

Samsung Galaxy S III
Price: £499.99
www.samsung.com

The marketing slogan Samsung has strapped to its new smartphone is: 'Designed for humans'. This had us wondering what other animals the South Korean tech giant has built phones for, but what Samsung is trying to say here is that the Galaxy S III is its most intuitive smartphone yet.

This is something you immediately notice when you pick up the phone. It comes with eye-tracking software that monitors your gaze, lighting up the display when you look at the screen and dimming it when you look away.

The interface will look familiar to anyone who's played with an Android device, but Samsung has peppered the phone with new software that makes it simpler and quicker to use. Take 'Direct call', for example, which automatically dials a contact when you hold your phone up to your ear. Or if you're a social networking addict there's 'Buddy photo share', which uses facial recognition to identify which of your friends are in your photos, and shares your pictures at a touch via Facebook, Twitter, email or MMS. And when you take pictures, the 'Best photo' mode will capture a burst of eight and select the best one (apparently it knows when you're looking your best).

The Galaxy S III is also one of the very first smartphones to offer genuine multi-tasking. On its generously proportioned 4.8-inch screen, you can select 'Pop-up play' while a video is rolling, to keep it playing in a portion of the screen while you send a text or browse the web.

Fans of the S III's predecessors might be a little disappointed that the specs haven't leaped forward as much as they'd have hoped. But it's encouraging to see a phone maker focus on what makes a smartphone special: its software.

KEY SPECS
OS: Android 4.0
Processor: 1.4GHz quad-core processor
Screen: 4.8-inch HD super AMOLED
Rear camera: 8MP with full 1080p HD video
Front camera: 1.9MP with 720p video
Dimensions: 136.6 x 70.6 x 8.6mm
Weight: 133g

Objects of desire

Snap happy

If you want to know what kind of features might be on your camera in five years' time, then it's worth taking a look at what's carried by professional-level devices now. Canon's new flagship DSLR, the EOS 1DC, is the company's first that's able to shoot in 4K resolution – that's more than four times the number of pixels in hi-def TV. It can also auto-focus on up to 61 points in a scene – perfect for keeping everything sharp in action-packed shots.

Canon EOS 1DC
Price: €10,000 (£8,052)
www.canon-europe.com

Space saver

USB's latest iteration, USB 3.0, transfers files at up to 600MB/s, which to most intents and purposes is near instantaneous. It's brought with it dozens of new memory cards and devices, but our favourite so far is the new LaCie FastKey. At 10cm long, it's not much bigger than a standard USB stick, but it can store up to 120GB worth of data. It also comes with security and encryption software to keep your files safe from prying eyes.

LaCie FastKey 120GB
Price: £350
www.lacie.com

Electric pedal power

You may pick up a speeding ticket riding this bike; it's so fast it's technically illegal to ride on British roads. At top speed, the Turbo reaches an impressive 45km/h (28mph), making it the fastest electric bicycle ever. Best of all, the battery – which will last for about an hour at full speed – is hidden away in the downtube so that other riders won't notice you're getting electrical assistance as you blast past without even breaking a sweat.

Specialized Turbo
Price: €5,499
http://turbo.specialized.com

Channel surfing

Your next TV set will most likely be able to access the internet, but browsing the web on a traditional remote is a bit like swimming through custard. So LG's new line of smart TVs is available with a Smart Control system. Like the controller for a Nintendo Wii, the TV tracks the wand's movements and duplicates them with an on-screen cursor, making navigating around the menus, apps and catch-up services quick and easy.

LG LM660
Price: £1,099.99
www.lg.com

Building blocks

Although 3D printers are supposed to make manufacturing easy for everyone, the printers themselves are actually quite tricky to put together at home. This irony hasn't been lost on the creators of Cubify, who've come up with this home-friendly model. The cartridges squirt a coloured plastic and are simple to load out of the box; one comes supplied with the unit. You needn't worry about the design software as it doesn't demand any previous experience and there's easy access to hundreds of 3D models online – from egg cups to combs to model planes.

Cubify
Price: $1,299 plus P&P (cartridges extra)
www.cubify.com

Tablet tunes

It looks like a tablet crossed with a piano keyboard, and that's precisely what it is. The top half is a multitouch-sensitive Android device that can be loaded with different apps for various musical approaches. The bottom half is a Yamaha audio engine that can synthesize the sounds of hundreds of instruments. The end result is an open-source device that programmers and musicians can toy with to make hundreds of new instruments and devices.

Miselu Keyboard
Price: TBC
www.miselu.com

Mind control: there's an app for that

The MindWave Mobile headset lets you control your smartphone using only your mind. Reviews editor and former neuroscientist **Daniel Bennett** tries it out

Can this headset actually read your thoughts?

In a manner of speaking. The headset reads distinct patterns of activity in the frontal lobe of your brain associated with attention and relaxation – it's essentially a simplified EEG scanner. This data is then fed into your phone, PC or Mac, where it can be used by apps and games. For example in *28 Zombies*, one of the simpler games we played, you could bend a spoon on-screen by focusing your attention. The harder we concentrated, the quicker the spoon would crumple, giving us a higher score.

Does it really work?

Impressively so. You have to find a quiet room first – noise and electrical appliances can interfere with its readings. Once you've downloaded the MindWave app and paired the headset and phone via Bluetooth, you're met with a calibration screen, which fills a bar according to your attention level. Trying to focus without a specific task in mind was tricky and it sent the meters all over the place. But once we did some tricky mental arithmetic the attention bar started to fill up pretty reliably. Relaxing again was tough, though deep, slow breathing paired with aimless window gazing seemed to do the trick.

What about the games?

There isn't much available for iOS and Android devices just yet, as the headset has only just gone on sale. Since the software is open source, developers will now be free to create apps of their own. On PC and Mac, the concentration and relaxation levels are used as extra inputs rather than a game's central mechanic. *MindBlaster*, for example, uses the mouse and keyboard to fly and aim your spaceship at enemy vessels. Once you've got your crosshairs on a foe, you have to concentrate to blow up the ship – it's incredibly satisfying and you get better with practice. The range of titles is pretty basic, and quite expensive, but this is all about the novelty of influencing on-screen events with your mind.

So why use it with a phone?

Admittedly you're not going to want to use this while you're out and about. And if you want it purely to play games with, then you'll probably stick to using it on a Mac or PC. But from a researcher's point of view, a small, relatively inexpensive device that you can carry around with you is invaluable tool.

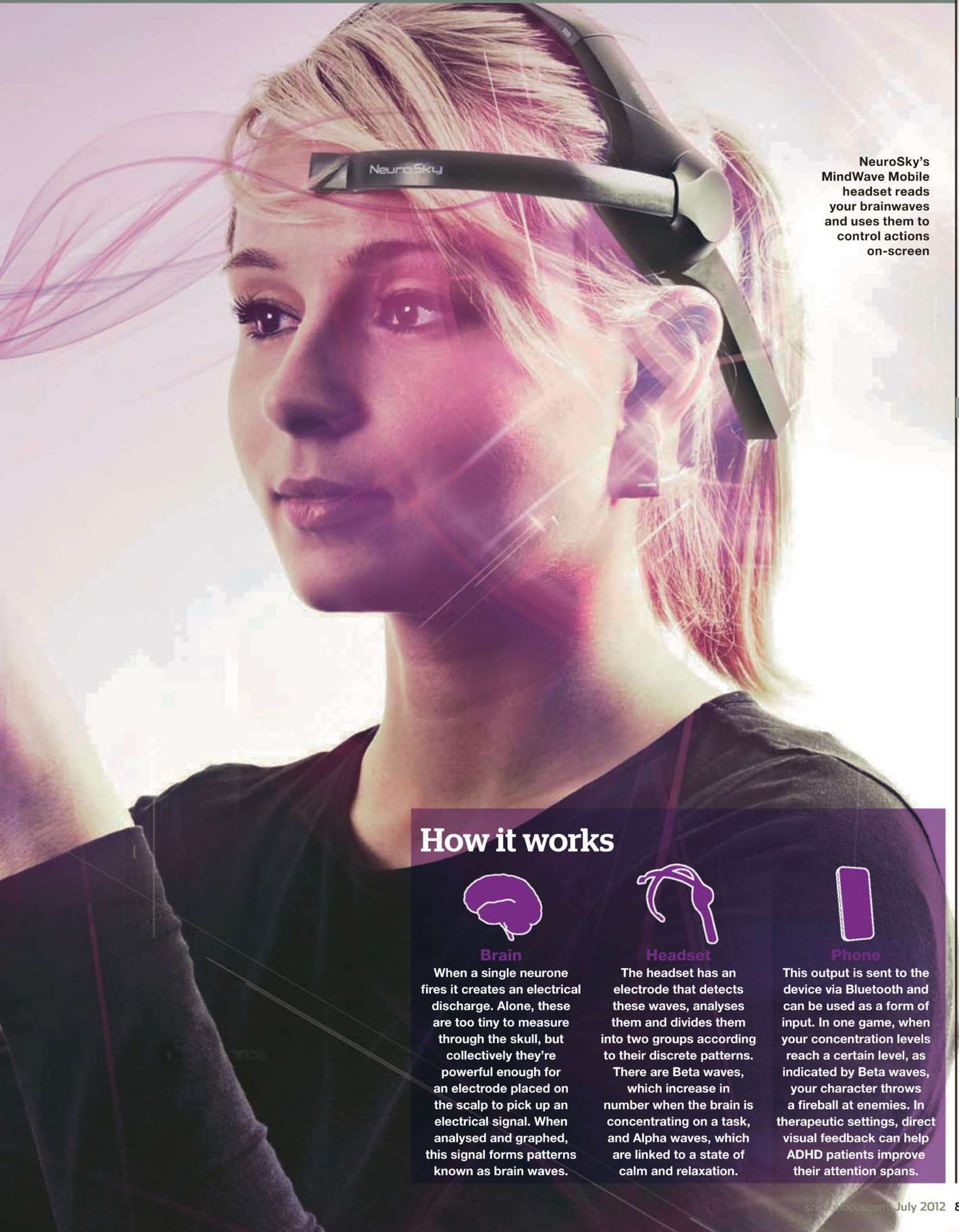
Plus, the headset and app only require a couple of minutes to set up, whereas a full EEG scanner and the software it requires can take hours. Of course, the MindWave headset is nowhere near as sensitive as an EEG scanner, but for some purposes it doesn't need to be.

Should I buy one?

Unless you have a serious fascination with the inner workings of the brain, $129 (£79.95) plus extra for each game is probably too high a price. But if enough research and educational facilities invest in the device, it'll only get better. Speaking to its developers, their goal is to make the headset cheaper and more sensitive. At the moment it can distinguish between two types of brain activity – they're hoping next-generation models will be able to read many more.

Price: €129 (£103 plus P&P)
Info: neurosky.com

WWW.STUDIO4PHOTO.CO.UK



NeuroSky's MindWave Mobile headset reads your brainwaves and uses them to control actions on-screen

How it works

Brain

When a single neurone fires it creates an electrical discharge. Alone, these are too tiny to measure through the skull, but collectively they're powerful enough for an electrode placed on the scalp to pick up an electrical signal. When analysed and graphed, this signal forms patterns known as brain waves.

Headset

The headset has an electrode that detects these waves, analyses them and divides them into two groups according to their discrete patterns. There are Beta waves, which increase in number when the brain is concentrating on a task, and Alpha waves, which are linked to a state of calm and relaxation.

Phone

This output is sent to the device via Bluetooth and can be used as a form of input. In one game, when your concentration levels reach a certain level, as indicated by Beta waves, your character throws a fireball at enemies. In therapeutic settings, direct visual feedback can help ADHD patients improve their attention spans.

RADIO STARS

We've come a long way since the humble transistor; **Russell Deeks** tunes in to the plethora of online stations while testing the latest digital radios

Why would I want one?

Simply because of the sheer number of stations available. All the radios in our round-up can receive both DAB (digital audio broadcasting) and FM transmissions, which gives you dozens of stations to choose from – you'll find a full list at www.ukdigitalradio.com. But they can also tune in to internet radio – and then you have access to thousands of stations worldwide. From talk radio to classical music, from smooth jazz to thrash metal, you can guarantee there's a station to suit your tastes. To give you an idea of the variety on offer, US-based 181 FM (www.181.fm) *alone* offers six different country & western stations, seven hip-hop stations, six dance/electronic stations, 10 rock stations, 10 pop stations and more besides… and that's just one broadcaster.

What else can these radios do?

The extra features vary from model to model. Some have a dock for your iPod. Those that don't come with an aux line-in, so you can still use them as a speaker system for your portable. Some sets enable you to access music recommendation services such as Last.FM, while others stream music from your PC or Mac via Wi-Fi. One model can even record a track from the radio to your portable, while Pure's Flow service enables you to purchase tracks you hear at the press of a button. Overall, it's fair to say they can transform the radio experience from one of passive, uncomplaining consumption into something more interactive and tailored to your musical tastes. So let's see how the different models compare…

WWW.STUDIO4PHOTO.CO.UK

What we looked for...

Sound quality

Obviously, the most important thing you want out of a radio is good sound quality… particularly if the set is to form the basis of a main living-room system.

Ease of use

Given the multi-talented nature of these radios, how easy is it to switch between sources and navigate your way around thousands of stations?

Looks and build

You don't just have to listen to the radio, it's also a piece of furniture you have to look at. Will it blend into your home, or stick out like a sore thumb?

Features

All of the radios here can receive DAB, FM and internet radio broadcasts… the devil is in the details, and specifically, in what *else* they can do.

Tivoli NetWorks+

£598 (second speaker £100) www.tivoliaudio.co.uk

+

The most expensive radio in our line-up by some way, the Tivoli is also one of the best-looking – it'll do any home proud where interior design is a high priority, especially since it's available in a range of colours.

The sound quality is also the best out of the group, filling the room with crisp highs, plenty of midrange detail and good solid bass. There are also bass and treble controls plus a range of EQ presets, so you can tweak the sound to your heart's content. As well as thousands of internet stations, it will also stream audio files stored on your PC or Mac over a Wi-Fi connection. On top of this, registering at Tivoliportal.com gives you access to music recommendation services.

–

To really get the most out of the Tivoli, you'll want to pair it with a second NetWorks+ speaker via the R-SPR port. The speaker will add another £100 to an already hefty price tag. The remote has cheap plastic bubble-style buttons and the blue-on-black display is quite hard to read from a distance – disappointing given the amount you're spending. There's no iPod dock, but on the other hand, if you like lots of bass, there is a dedicated subwoofer output.

Sound quality: ●●●●●
Ease of use: ●●●●○
Looks & build: ●●●●○
Features: ●●●○○
Overall: 16/20

Size: 140 x 222 x 130mm
Sources: DAB, FM, internet, streaming from PC/Mac, line-in
I/O: USB, 3.5mm aux in, 3.5mm mix in, Ethernet, sub out, rec out, headphone socket, R-SPR port
Power: Mains or 12V DC
Power output: 10W

Roberts Stream 63i

£350 www.robertsradio.co.uk

+

The Roberts radio is the 'do it all' model in our round-up. Not only is it a DAB, FM and internet radio tuner, it's also a CD player and iPod dock, and it's got SD card and USB slots as well… so it should be able to play music in pretty much any digital format you throw at it. It'll stream music files from Mac or PC – even machines running Linux – and you can record from radio broadcasts to your chosen digital media. Sound quality is good: it's not quite up there with the Tivoli in this respect, but it does fill the room with music well. We liked the clearly labelled buttons on the front panel, too – minimal design is all very well, but pressing a button beats scrolling through sub-menus every time!

–

On the looks front, you're either going to appreciate the 'classic hi-fi' stylings of the Stream 63i or you're not – some may find it a little 'old school', especially given that it's only available in black. And, while it certainly offers decent sound quality, it can be a case of 'punch over definition'; if you're a bit of an audiophile you will probably want to look elsewhere. CD playback, in particular, proved to be something of an Achilles' heel in this regard.

Sound quality: ●●●●○
Ease of use: ●●●●○
Looks & build: ●●●●○
Features: ●●●●●
Overall: 17/20

Size: 358 x 160 x 220mm
Sources: DAB, FM, internet, streaming from PC/Mac, SD card, CD, iPod dock, line-in
I/O: USB, Ethernet, S/PDIF, 3.5mm line out, 3.5mm aux in, headphone socket
Power: Mains
Power output: 12W

WWW.STUDIO4PHOTO.CO.UK

Roth KRadio

£149 www.rothaudio.co.uk

Size: 280 x 127 x 120mm
Sources: FM, DAB, internet, streaming from PC/Mac, iPod dock, line-in
I/O: LAN, 3.5mm aux in
Power: 12V DC
Power output: 10W

+

If you're looking for a compact system for the bedroom or kitchen, the Roth KRadio is definitely worth a look. It's somewhat akin to a scaled-down version of the Roberts in the looks department, and features a similar array of buttons on the front panel. These are backlit, which combined with the clearly legible white-on-blue display, definitely won it some points, as did the fact that it's the only radio here that displays 'now playing' track information by default.

There's an iPod dock, and you can also stream music from your PC and Mac. All this can be controlled with a non-cluttered remote. For the modest asking price, this well-designed entry packs in quite a lot.

–

Although there's a lot to like about the KRadio, the affordable price tag is reflected in the sound quality. It sounds brash and brittle compare to the Roberts and Tivoli models, and you're very conscious that you're listening to a small box in the corner. The absence of any EQ controls doesn't help and there's no headphone socket – a pretty serious omission. While the touch-sensitive buttons look nice they do feel a little cheap, as does the rather frail remote.

Sound quality: ●●●○○
Ease of use: ●●●●○
Looks & build: ●●●○○
Features: ●●●●○
Overall: 14/20

Pure Oasis Flow

£135 www.pure.com

+

The Oasis Flow has one major plus point – you can take it outside, even in the rain, making it ideal for barbecues or camping. There's a nice, clear yellow-on-black display and it will also stream music from your Mac or PC. The sound quality is acceptable, though not breathtaking.

Registering with Pure's comprehensive 'Lounge' service gives you access to music recommendations and enables you to organise stations into folders – great if the whole family are using the radio. The Lounge also includes Pure's FlowSongs system, whereby you purchase a song at the touch of a button if you like the sound of it – a truly innovative idea.

–

For a portable system, the Oasis Flow is pretty heavy at 2.2kg. We'll forgive it its somewhat convoluted operation – buttons have to be kept to a minimum to maintain its weatherproofing after all, and the touchscreen does make life a little easier. But positioning the 'Off' button right below the 'OK' screen option wasn't helpful! There are no EQ controls or iPod dock, either – and worst of all, we experienced several drop-outs when listening to internet radio.

Sound quality: ●●●○○
Ease of use: ●●●○○
Looks & build: ●●●●○
Features: ●●●●○
Overall: 14/20

Size: 155 x 230 x 140mm
Sources: FM, DAB, internet, streaming from PC/Mac, line-in
I/O: Mini USB, 3.5mm aux in, headphone socket,
Power: 12V DC or optional ChargePak battery unit
Power output: 10W

BBC History magazine

Passionate about history?

BBC History Magazine gives you a rich and resonant diet of stimulating and entertaining features from the world's leading historians. Never dull, always informative, it's your window to the past

Claim your FREE issue today*

Call 0844 776 0282+ quoting FOHA12FRE
for your FREE issue now*

There are no obligations or catches!

+ Order lines are open Monday–Thursday 9.30am to 8.45pm, Friday 9.30am to 8.15pm and Saturday 10am to 1.45pm. Calls will cost 5p per minute. Calls from mobiles and other providers may vary.

* This offer is available for UK delivery addresses only and is subject to availability. Your free issue will be the July issue mailed mid-July if you call before 5 June or August issue mailed mid-August if you call after 5 June. **Offer ends 27 June 2012.**

Spencer Kelly

Robotic overlords

Slowly, cautiously, I edged towards the rectangle of light on the floor. Two more steps, and I'd reach it… one more… but then, with a grating mechanical whirr, I was swung round to face away from my goal. My robotic master had spoken.

I was wearing 'Compass', a frightening-looking metal belt which sensed where I was in the room, and prevented me from walking into the lighted floor areas by spinning hefty weights, forcing me to turn in the opposite direction.

My "human-robot reorientation" took place at a Liverpool techno-art exhibition exploring a future where we trust machines enough to physically move us about. I love these kinds of events – after all, it's often the creatives, be they artists or sci-fi authors, who, free from commercial interests, come up with the really visionary stuff.

In the future, will we need to belt up just to go for a stroll?

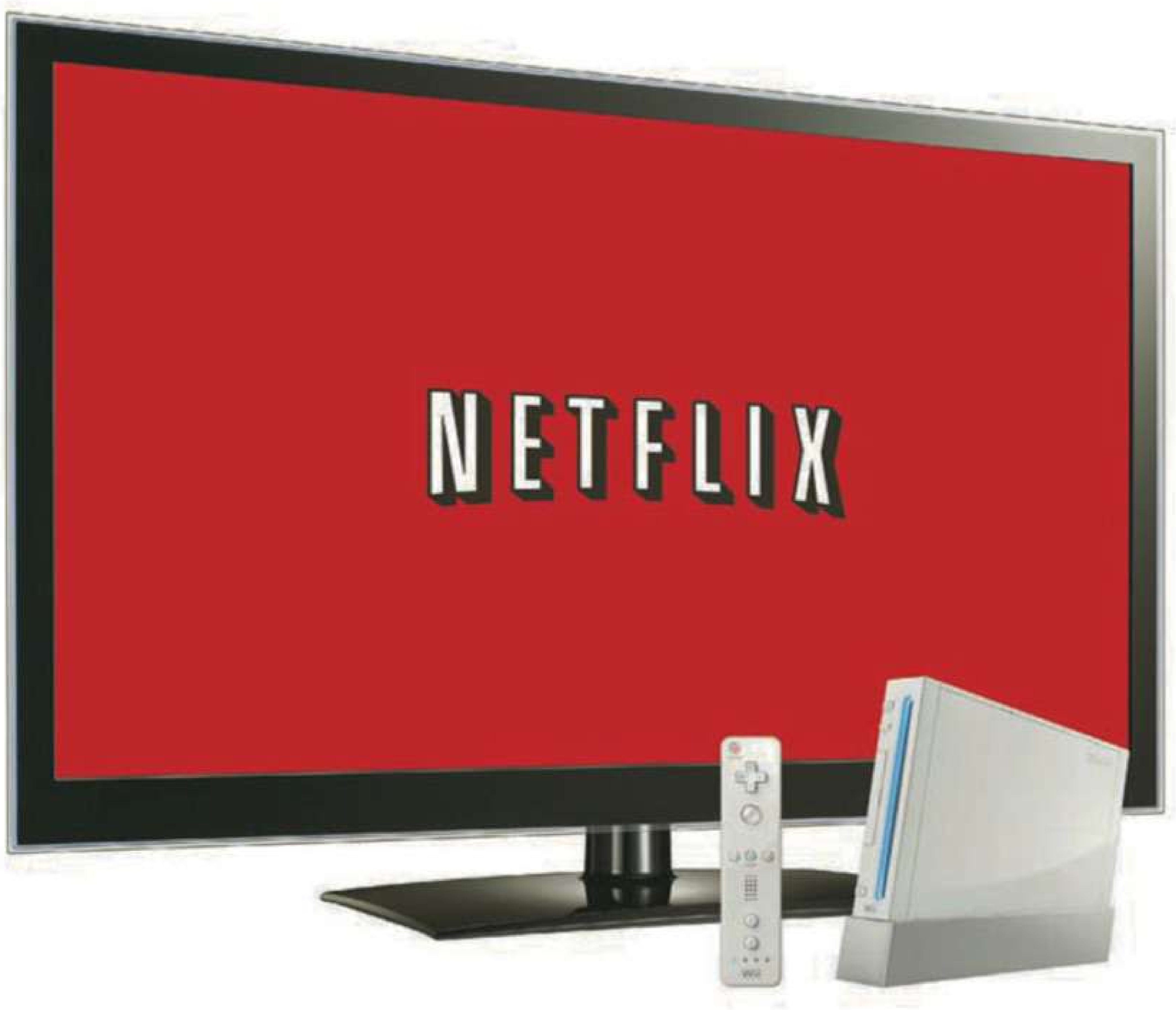
Robot Wars judge Prof Noel Sharkey, who also tried the contraption, predicts that in this machine-controlled future, "There will be two personality types – those who resist, and those who surrender". I'm definitely the former – just ask my poor sat-nav. I seem to remember giving the Microsoft Office paperclip a pretty hard time, too.

I'm not sure if I simply don't trust artificial intelligence yet, or if I have an issue with a machine making better decisions than I can. But in a few decades' time, when our shoes have built-in navigation, I'll be the one looking like I'm wading through treacle as I battle my left-turning loafers.

Spencer Kelly is the presenter of the BBC's technology show *Click*

How to... STREAM FILMS AND TV

For around £5 per month you can enjoy Hollywood's finest with a subscription to a web-based video service



Check your speed

First, make sure your internet speed and download limits can cope. Use a site like www.mybroadbandspeed.co.uk to measure the speed of your connection during peak hours (6-11pm), when transfer rates are typically slowest. Lovefilm suggests a line speed of 2MB/s (16Mbps) for optimum viewing. To avoid nasty bills or getting your connection restricted, it's best to opt for an internet provider that offers unlimited broadband.

Get a set-top box

If your connection is okay, then you need a device that will give you access to all the free TV the net has to offer, plus subscription services like Lovefilm and Netflix. The Xbox 360, PS3 and Wii all do this, but if you don't own a console there are set-top boxes that'll do the job. The winner in a *Focus* test was the Boxee, which harvests all the free TV available and presents it in a neat interface that includes Netflix content.

Netflix or Lovefilm?

Have a look at both – they offer a month's free trial before you commit. But if you're a movie buff then Lovefilm, as its name suggests, is probably the best bet: it has a far richer film library than Netflix, having secured deals with most of the large movie studios (bar Universal). Netflix offers more TV series, especially US shows. But you're not tied in to either for longer than a month, so you can always switch if you want to.

Tech Doc's App Prescription

Fragile Earth

iPhone, iPad £1.99

Filled with stunning photos and satellite images, this app shows the effect on our planet of climate change, urbanisation and natural disasters. From the drying Aral Sea to the Japanese tsunami, you can swipe between pictures of the same area taken at different points in history to see just how quickly it's changed.

The Social Radio for Twitter

iPhone Free

No time to read your Twitter feed? Then have your timeline read to you by The Social Radio, which dials into your Twitter account at regular intervals and speaks what it finds. You can even add some of your favourite music if you like, to make it even better than Radio 4 (possibly).

NETFLIX

The latest season of *Booze Britain* got off to a flying start

RESIDENT EVIL 6

PS3, X360, PC
Capcom, £39.99

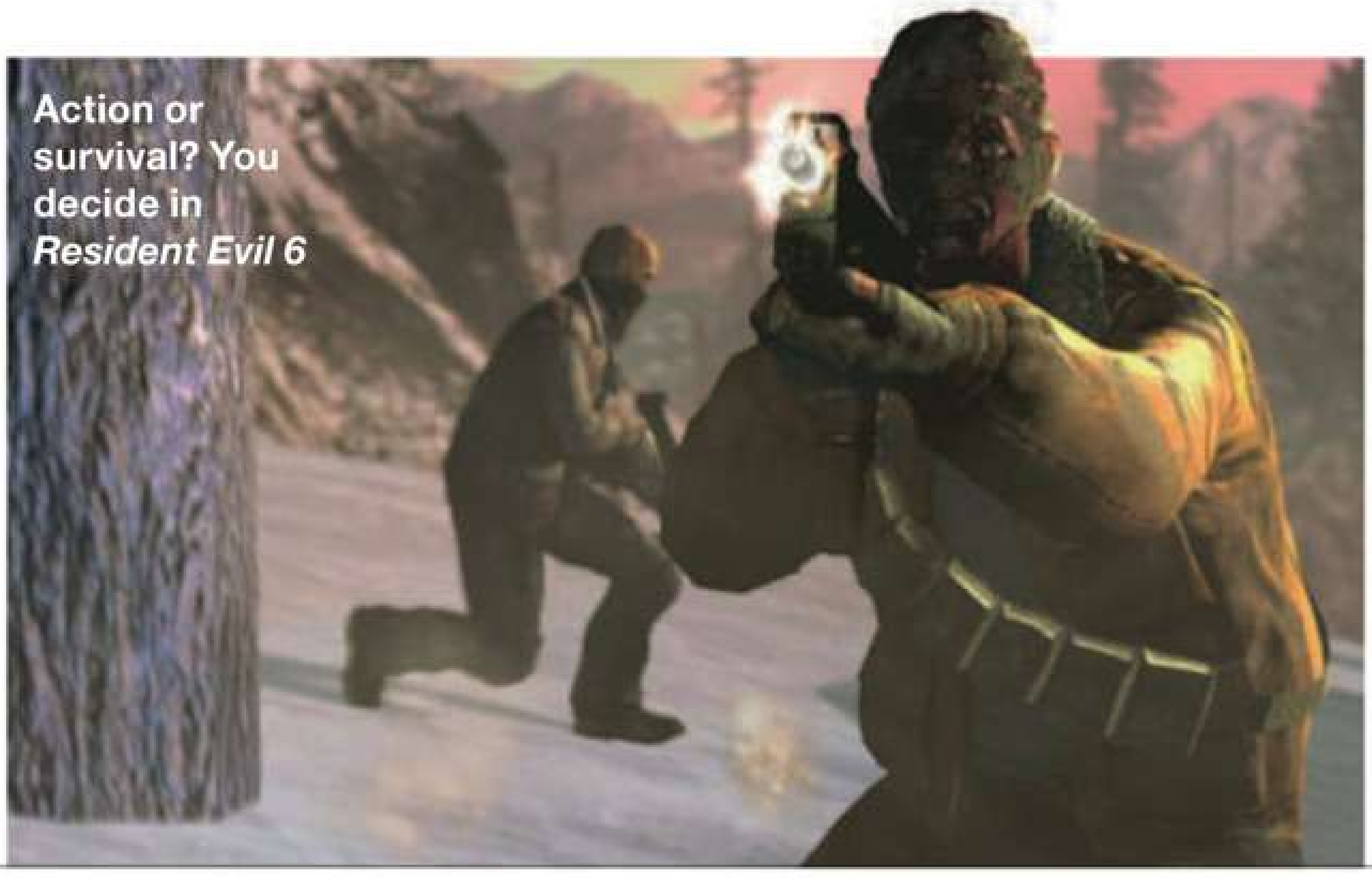
Like the mutant abominations that stalk its protagonists, the long-running *Resident Evil* series has morphed from its original form almost beyond recognition.

The first game, released for the PlayStation in 1996, was a slow and atmospheric number, from which legions of modern horror games can trace their roots. *Resident Evil 5*, released in 2009, was all-out action, set in a fictional African nation plagued by quick-moving ghouls.

But *Resident Evil*'s evolution from survival horror towards action spectacle hasn't pleased everyone. So *Resident Evil 6* is out to make amends to old fans and cater to gun-happy action gamers all at once. How? By using a trio of protagonists, each with their own storyline.

Series veterans Leon Kennedy and Chris Redfield star together for the first time, with Leon's path most resembling classic *Resident Evil* and Chris's standing for the franchise's more modern action focus. The third hero, Jake, is a wild card. In keeping with the schlocky soap opera charm of the series' lore, he's the estranged son of megalomaniacal villain and fan favourite Albert Wesker.

It may be that *Resident Evil* can never fully go back to its idiosyncratic horror roots, but we're hopeful it can blend a satisfying variety of experiences with a multi-character approach. Especially given the purported length of the game – at 30 hours or so you'll be blasting enemies for well over twice the amount of time you did in the last one.



Action or survival? You decide in *Resident Evil 6*

ALSO OUT

STEEL BATTALION

Xbox 360
Capcom
£39.99

A world apart from the dance and party games that are Kinect's bread and butter, *Steel Battalion: Heavy Armor* crams you and a three-man crew inside a hulking, clanking two-legged tank. You steer through intense, near-future battlefields and order strikes using hand gestures. If you've been yearning for a serious motion-control game, this is well worth checking out.

DARKSIDERS II

PS3, X360, PC
THQ
£39.95

You play as Death in this action-adventure sequel, scything through ethereal realms to clear the name of War, the star of the first game. Death brings nimbler moves to the party, which again draws deftly on classics *Zelda* and *God Of War*. Though unlike these series, which have gotten easier over the years, this sequel looks to be even tougher than the original.

GAMESPRESS X5

Jane Douglas

Sci-fi dilemmas

Like so much great science fiction, the space opera *Mass Effect 3,* last in the blockbusting trilogy, populates the galaxy of its far-flung future with many an idea grounded in our present day.

At the heart of one of the game's subplots is the genophage: a biological weapon engineered by an advanced race for specific use against a brutish one (the Krogan). The weapon, a kind of infection, induces a genetic mutation in Krogan females that keeps them from carrying pregnancies to term. It's a 'non-violent' measure taken to suppress reproduction in a warlike race, with species-wide extinction the likely outcome.

Compare that to recent work by a UK team that genetically modified male mosquitoes which, when mated with wild female mosquitoes, produced sickly offspring that die in the pupae stage – that is, before spawning young of their own. The research group, led by Oxford University spin-off firm Oxitec, said the method could cut the numbers of mozzies carrying dengue fever and similar diseases, and so reduce infection rates in humans. Again: a dangerous species culled without killing.

Mass Effect 3: swatting the odd mosquito is a lot easier

In *Mass Effect 3*, you have the choice to maintain the genophage or develop a measure to reverse it – saving the beleaguered species from extinction while risking a population boom and aggressive, bloody expansion.

In its own way, it invites you to ponder questions about genetic tinkering. And in doing so, it forms another piece in the increasingly convincing argument that games can be just as thought provoking as their celluloid- and paper-bound counterparts.

Jane Douglas is section editor of GameSpot UK

Relive your holiday memories, over and over again...

Verbatim gives you the choice to back up your memories on USB 3.0 500GB and 1TB Hard Drives and matching 4GB and 8GB USB Drives in your own favourite colours.

www.verbatim-europe.com

STAPLES
that was easy.

currys

PC World

Verbatim.
Technology you can trust

inspiration to
live a greener life…
abrandnewyou.co.uk
DREAMSTIME.COM

Bill Thompson

A quick billion

I'm old enough to remember when every small company writing Windows software feared the day they'd get a call from Microsoft offering to buy it, usually at a price below what the company thought it was worth. If they turned down the offer, Microsoft would develop its own version of their offering and destroy whatever market share it had – or just announce its intention to do so, creating enough uncertainty to force the small company back into negotiation.

That probably wasn't a problem for the developers of photo editing and sharing app Instagram earlier this year. Facebook's offer of $1 billion in cash and shares was almost certainly more than their wildest dreams, and they accepted with alacrity. But this move has worried a lot of people who enjoyed Instagram for its simplicity and ease of use. They fear that it will end up being absorbed into Facebook as just another component of an increasingly complex user experience. And it leaves open the question of what happens to the data associated with each Instagram photo, like the location of the person who took it. Facebook will, no doubt, find imaginative ways to use this data to target advertising more precisely, as well as improve its own mobile photo-sharing services.

This sort of consolidation is not unique to the online world or even to computing. The great media consortia that control much of what you read, see and listen to were assembled over the years, and industrialisation is characterised by this sort of consolidation and consequent break-up of great companies. Google and Facebook are just the latest examples.

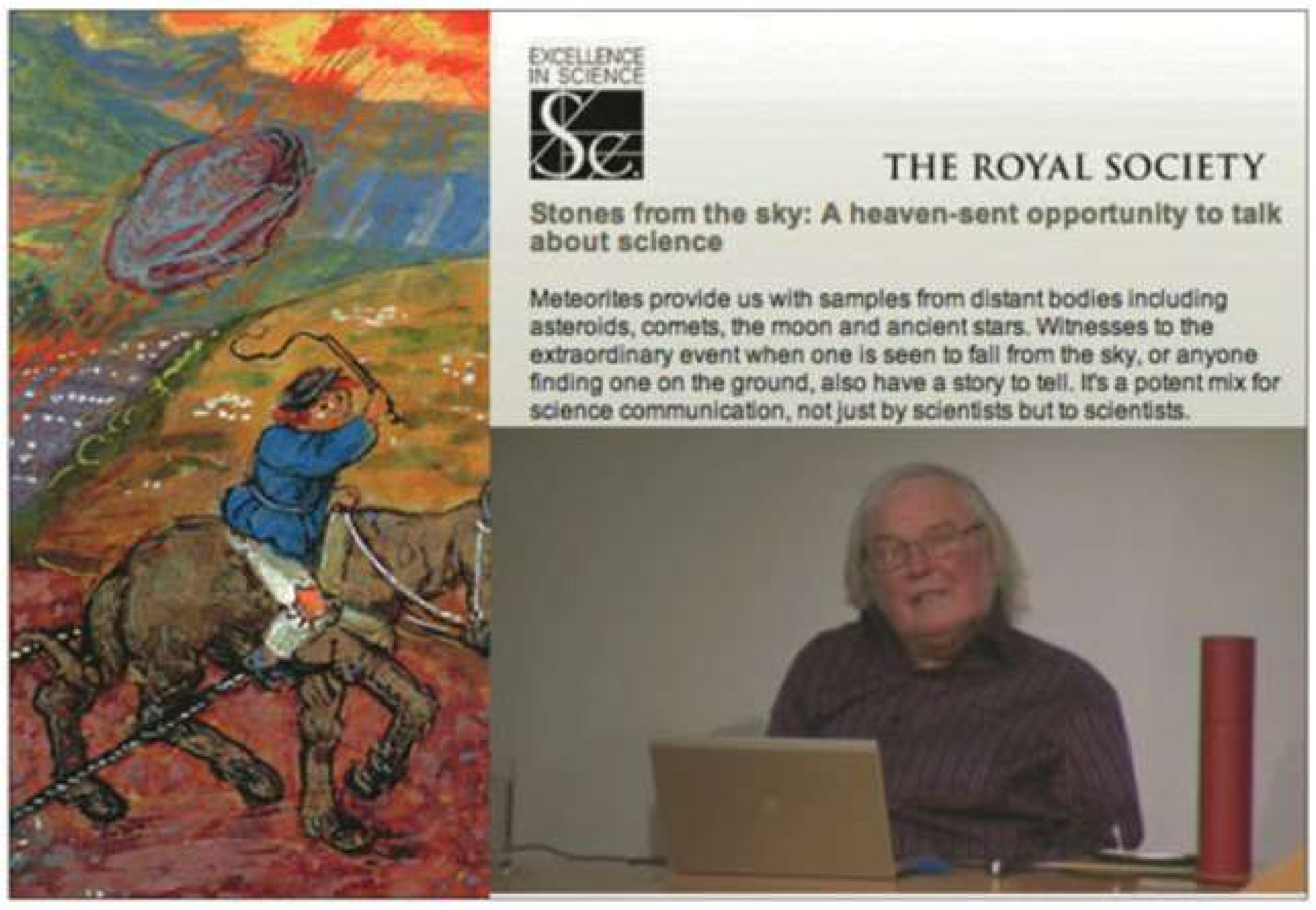
If there's a difference now, it's the speed with which a company can be formed, grow and then be acquired – Instagram was only 18 months old. Although Instagram doesn't seem to have been designed to be sold quickly, there is a risk that other developers will see its success and become more focused on being targets for acquisition by the big online companies – stifling creativity and variety in the first place.

For those of us who spend a lot of our time online, this rapid pace of change is disorienting. The community that builds up around a social media service are like the first inhabitants of a new town or village. They develop connections that are precious to them, and they might not be too pleased when the Google shopping centre or the Facebook retail park come to town.

Bill Thompson contributes to news.bbc.co.uk and the BBC World Service

Royal Society Lectures

royalsociety.org/awards/michael-faraday-prize



EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

Stones from the sky: A heaven-sent opportunity to talk about science

Meteorites provide us with samples from distant bodies including asteroids, comets, the moon and ancient stars. Witnesses to the extraordinary event when one is seen to fall from the sky, or anyone finding one on the ground, also have a story to tell. It's a potent mix for science communication, not just by scientists but to scientists.

As the Royal Society prepares to award its annual Michael Faraday Prize for excellence in scientific communication, it's an appropriate time to catch up with last year's winner in this online video. Prof Colin Pillinger's lecture, 'Stones From The Sky', covers the history of meteorites. It includes the fascinating story of how Britain's oldest and biggest space rock ended up on the steps of a Wiltshire manor house, unrecognised for decades. As an additional flourish, the lecture's presentation slides run alongside the video. It creates a rich experience, and is about as close as you can get to actually attending the lecture yourself.

And once you've had your fill of meteorites, there's plenty more on offer, including a talk from Sir David Attenborough on his career in natural history and one from Marcus du Sautoy on mathematics in art.

WEB HACKS

Convert files quickly and easily with Zamzar.com

What? With hundreds of different formats for images, documents, spreadsheets, music and video, reading files from other people can be a real pain. Zamzar converts them to suit your needs.

Why? There are other ways to convert a file into something you can use, such as uploading it to Google Docs, but Zamzar is a dedicated, simple service rather than part of a larger site.

How? Upload your file – it can be up to 100MB, but it does offer a paid-for service that supports larger files and online storage options – and Zamzar will turn it into something readable for you to download. You can even convert by email, which will be particularly helpful for smartphone users. Email your file to format@zamzar.com and the result comes back changed. For example, doc@zamzar.com will convert the file into a Word document; use jpg@zamzar.com to get a JPEG image and so on. As with any online service, you should think twice about using it for sensitive or confidential files. Zamzar has to read your file to convert it, and it doesn't use a secure connection to upload or download your files.

Cambridge Digital Library: Newton Papers

cudl.lib.cam.ac.uk/collections/newton

A historic manuscript on screen will never be a true substitute for the physical object, which carries with it the aura of the ages. However, these high-resolution scans of Isaac Newton's papers are remarkable and compelling, and sufficiently detailed to deserve close scrutiny. My favourite is the 'Waste Book' from 1664, in which you can see how he developed calculus, but they are all fascinating and worth careful examination.

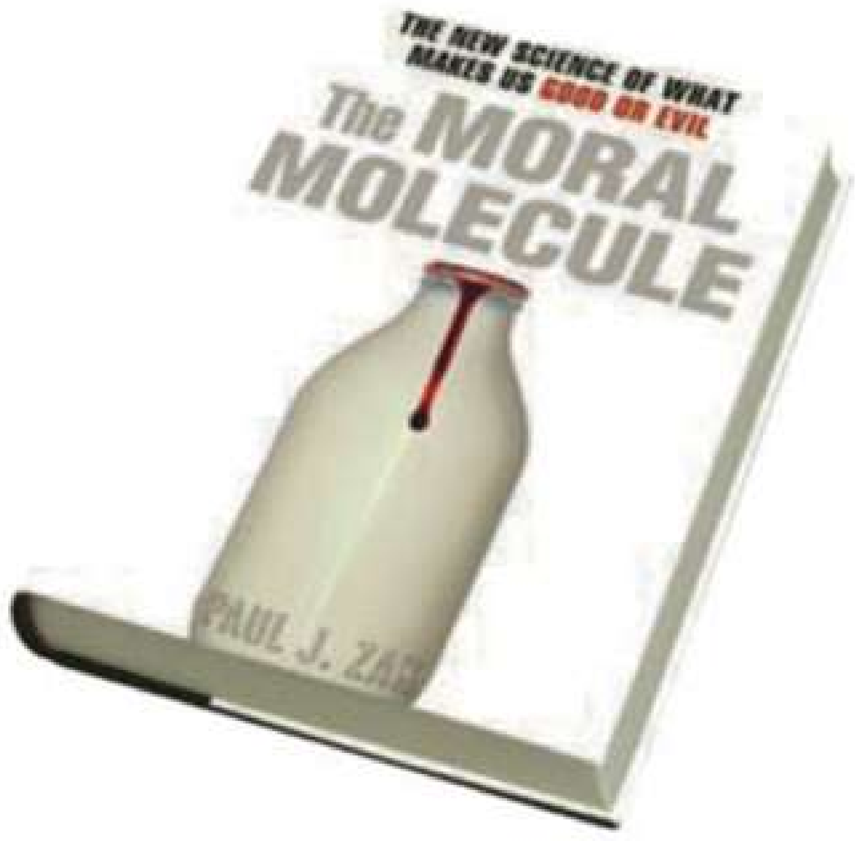
Eyes On The Earth

climate.nasa.gov/eyes

In 1968, I had posters of Apollo 8 on my bedroom wall and followed the first astronauts to the Moon and back. A modern equivalent would be this NASA site, which uses satellite data to produce visualisations of Earth showing temperature, CO_2 levels and more. You can also track satellites in orbit. You'll need Java to run it, and it's a fairly hefty download, but it's worth it for the beautiful images and engaging interactivity.

The Moral Molecule

One solitary hormone can't explain morality but this is still an engaging read, says **Mark Pagel**



The New Science Of What Makes Us Good Or Evil
Paul J Zak
Bantam, £16.99
(hbk, 256pp)

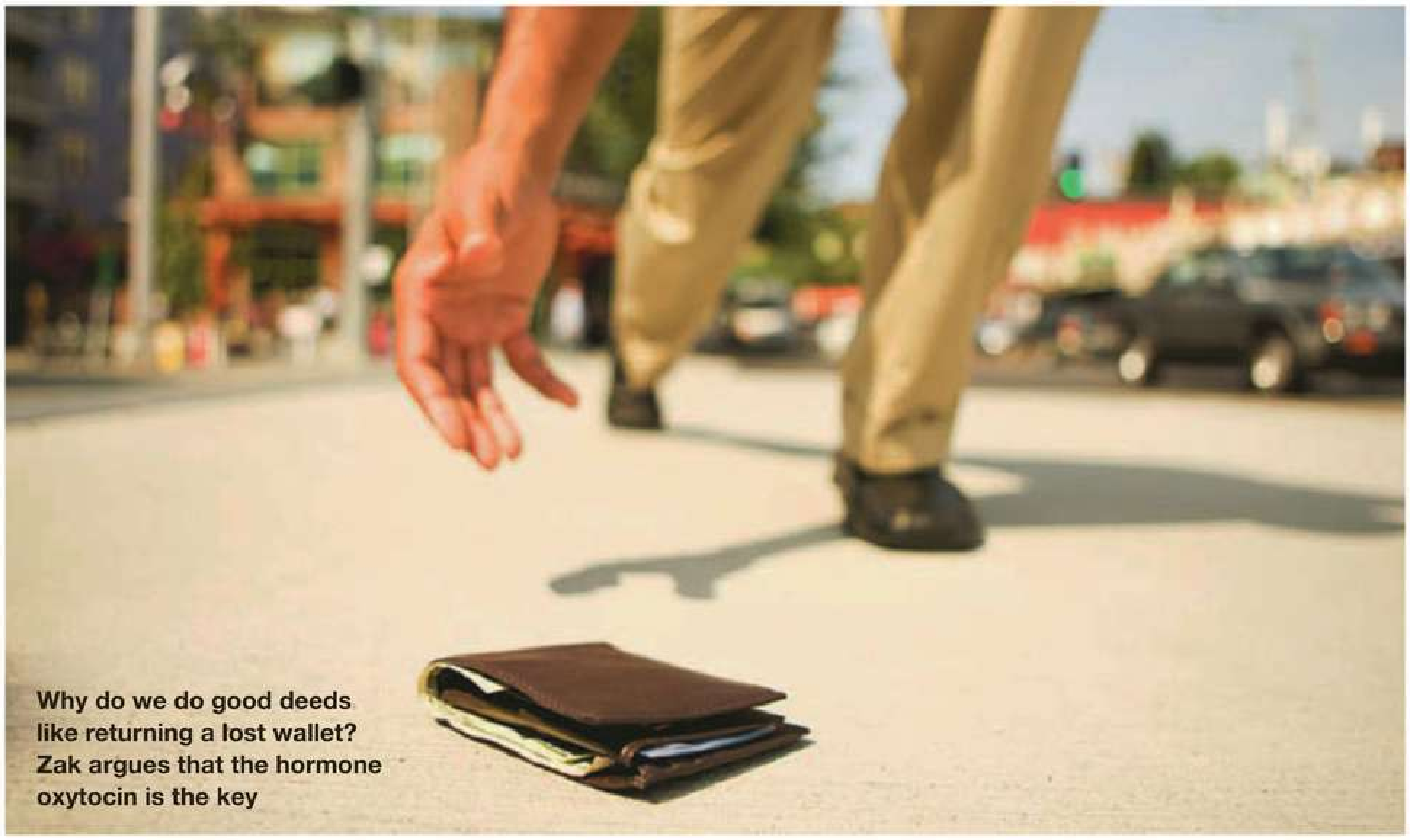
When humans are bad, we can be very bad. But when we are good, we can be *very* good – more so than any other animal. Paul Zak is interested in the good stuff – all those 'pro-social' things we do, like returning lost wallets, holding doors for people, or even jumping into a river to save someone. And he thinks he has found the cause of these actions: an ancient hormone called oxytocin, which he calls the 'moral molecule'.

Oxytocin is the hormone that induces labour in mammals and then influences the bond between mother and baby. But Zak has discovered that its effects extend to emotions related to other social behaviour. He finds that when people cooperate, trust each other, or even just have a hug, they have higher levels of oxytocin. And if an oxytocin-laced mixture is sprayed into your nose, you get the warm fuzzy glow we associate with kindness and generosity.

So are we just emotion-robots under the spell of oxytocin? Well, yes and no. Our species has taken the ideas of cooperation and sociality further than any other animal. To encourage that cooperation, natural selection has given us emotions that make us feel good when we do. And oxytocin helps to create those emotions, playing a role similar to the performance-enhancing drugs some athletes use. Those drugs aren't the reason why athletes compete, but they can improve their performance. Similarly, oxytocin isn't why we cooperate, but it rewards us when we do.

The real wonder of Zak's engaging book is that natural selection has been so creative in helping us to behave in ways that benefit our survival and well-being – in the case of oxytocin, roping in a hormone originally involved with childbirth to do the job. ●●●○○

***Prof Mark Pagel is a biologist and author of* Wired For Culture**



Why do we do good deeds like returning a lost wallet? Zak argues that the hormone oxytocin is the key

GETTY

Author Q&A

Paul Zak on *The Moral Molecule*

Why did you decide to write this book?

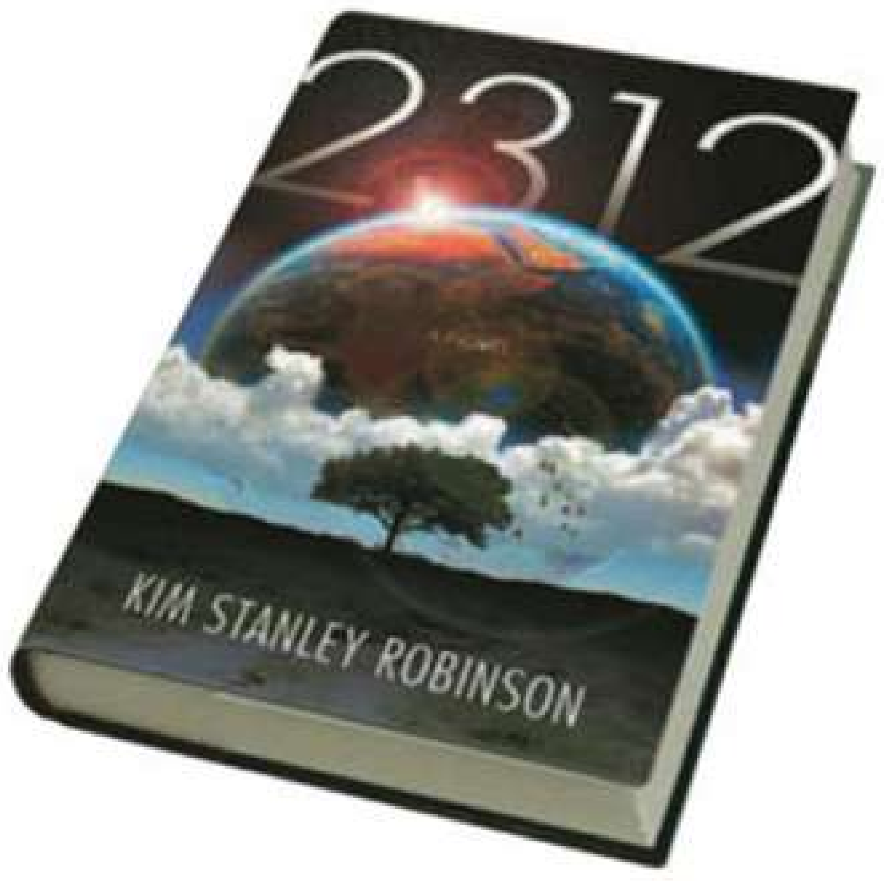
It's a fascinating, understudied area. It's the longest debate since humans started having debates: are we good or evil? I wanted to go further than just saying that we're social creatures and therefore we behave well most of the time. I wanted a concrete answer, and brain chemicals are concrete because you can both measure and manipulate them. It's been a 10-year odyssey in the lab, and the accumulation of findings all started pointing in the same direction, which is that oxytocin is a thermostat that turns moral behaviours up or down.

What surprised you most?

Oxytocin responds subtly to social situations. A great example is the wedding experiment that starts the book. I took blood before and after the wedding vows, and found that the impact of this ritual was reflected in its importance to the people around it. So the bride had the biggest oxytocin release, then her family, then the groom, then his family and finally their friends. These rituals bring us together as a community. I hypothesised that this occurs because it provides social support so that they'll be successful at reproducing, because we all have a stake in perpetuating the species.

Which part of the book was most challenging?

The hardest chapter was on religion, because of my own background. My mother had been a nun, so as a child, notions of morality – "Do this or you'll go to Hell!" – pervaded the household, and they didn't make sense to me. I was looking for my own answers that didn't depend on a God or a government telling us what to do – a biological reason.



2312

Kim Stanley Robinson
Orbit, £18.99/£8.99
(hbk/ebook, 576pp)

As its title suggests, Kim Stanley Robinson's new novel is set three centuries from now. Mankind has colonised the Solar System in all manner of exotic ways. On fiery Mercury, for instance, a city trundles forever westward to stay ahead of the scorching Sun, while asteroids have been hollowed out to provide habitats that double as havens for wildlife.

Sounds idyllic, except that spacefarers are a privileged elite whose vulnerability is cruelly exposed by an unprovoked attack. Who's attacking, and why? Moreover, can any elite class truly be said to be prospering if it fails to address the problems of an underclass – in this case, those left behind on an Earth ravaged by climate change?

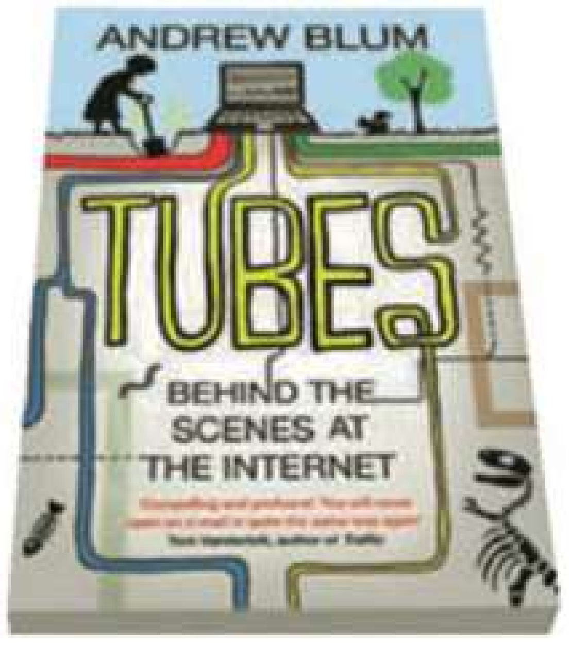
Exploring these questions largely through the eyes of performance artist Swan and Saturnian diplomat Wahram, Robinson conjures up a utopian-tinged vision of what a post-capitalist society might look like. In a book that sprawls somewhat but always holds the attention, he also weaves in such themes as machine intelligence, inter-sexual politics and environmentalism. Like Robinson's classic *Mars* trilogy before it, this is science-fiction that is big-hearted, pointedly allegorical and unapologetically political. ●●●●○

Jonathan Wright is a journalist and science-fiction expert

Tubes

Behind The Scenes At The Internet

Andrew Blum
Viking, £12.99/£7.99
(pbk/ebook, 304pp)



When a squirrel chewed through a cable at his home in Brooklyn and brought down his internet connection, technology writer Andrew Blum didn't just call out an engineer. Instead, he decided to go off in search of the 'real' internet – the computers, fibre-optic cables, routers, buildings and organisations that together make up the internet's global network and give us an unprecedented ability to communicate with each other.

Blum manages to explain how the internet works without drowning in too much technical information. Instead, he focuses on some of the key people involved, from network engineers to the people who lay transatlantic cable. He travels to office blocks crammed with cables and routers – the computers that move traffic from network to network and make it possible for emails, web pages and videos to move around – and uncovers the internet's early history, including a fascinating account of how the old New York telegraph system shaped the way net cables move through the city.

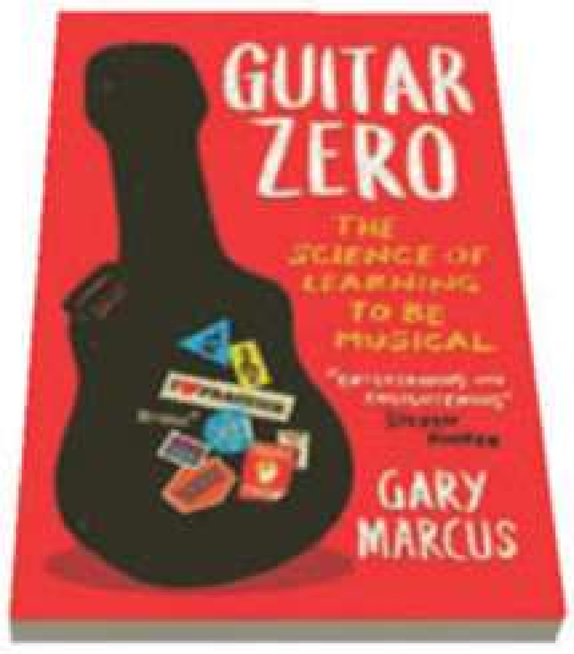
Blum also travels to Porthcurno in Cornwall, where the first transatlantic cable began. By the time he's done, you'll have a much clearer sense of the network that moves your data around. ●●●●○

Bill Thompson is a technology critic and* Focus *columnist

Guitar Zero

The Science Of Learning To Be Musical

Gary Marcus
Oneworld, £12.99
(pbk, 304pp)

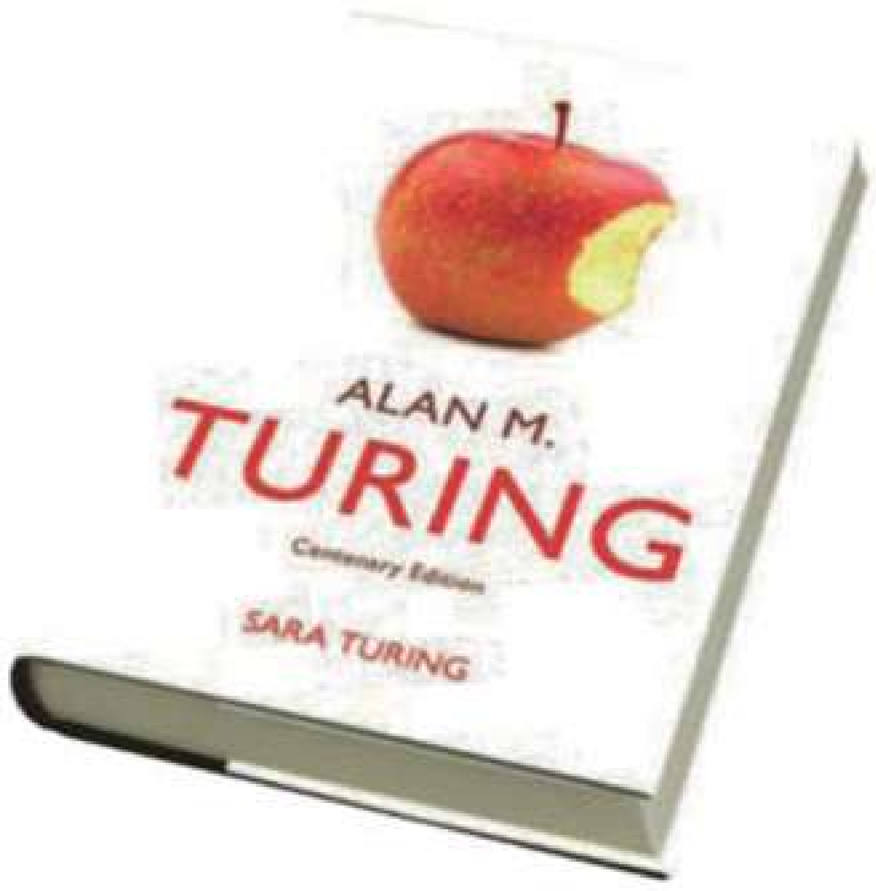


At the age of 38, "congenitally arrhythmic" psychologist and occasional *Guitar Hero* player Gary Marcus decided to learn the instrument proper, and write a book about it in the process. As a 38-year-old guitarist myself, I can empathise – the stages of learning he describes are the very same ones I must have passed through unknowingly as a teenager.

Marcus's story marks time with chapters reviewing the scientific literature on musicianship, especially those related to adult learning. It's an easy read and uncovers some interesting facts: learning new things, Marcus reports, causes a surge in dopamine levels not dissimilar to that caused by crack cocaine.

Despite meeting luminaries such as Tom Morello of Rage Against The Machine and jazz legend Pat Metheny, Marcus manages only a modest level of skill after two years of trying. Perhaps that's not surprising. The total amount of time he's able to practise adds up to a few hundred hours – a long way from the thousands of hours that scientific studies agree it takes to become a bona fide guitar hero. But adult wannabes shouldn't be discouraged. If this book had a chorus, it would scream: "There's still hope!" ●●●○○

Dr Mark Lewney is the 'rock physicist' and FameLab alumnus



Alan M Turing

Centenary Edition

Sara Turing
Cambridge, £19.95
(hbk, 194pp)

What do you know about Alan Turing, one of the greatest minds of the 20th century? You probably know he was a mathematical genius who helped create modern computer science, cracked the Nazi Enigma code, then killed himself two years after being convicted of being gay and chemically castrated.

So who better to write about his life and work than his mum, who knew little about maths or computers, nothing about Enigma, and regarded homosexuality and suicide as a sin? Sara Turing penned her recollections 50 years ago, and now they've been reprinted, along with a memoir by Alan's older brother, as part of the celebrations marking the 100th anniversary of the birth of the brilliant but tragic Turing.

Yet without access – either intellectually, emotionally or (because of secrecy rules) officially – to the key issues of her son's life, they read like a school report. As such, this book holds interest and entertainment only for the most determined Turing collector. Far better to save your money for the forthcoming new edition of *Alan Turing: The Enigma* by Andrew Hodges, regarded by many as one of the greatest biographies of anyone, let alone Turing. ●○○○○

Robert Matthews is visiting reader in science at Aston University

THE TO-DO LIST

The essential guide to the month ahead

5 JUNE

Constructing The Heavens

Uranus was William Herschel's killer discovery but, with his sister and son, he also compiled a catalogue of 2,500 night-sky objects, including distant galaxies. This exhibition recreates Herschel's work with modern images.

Herschel Museum Of Astronomy, Bath, until 16 December, £5 or free with museum ticket, www.bath-preservation-trust.org.uk

12 JUNE

SPEAKER OF THE MONTH

Dr Chris Arridge

Who is he?

Dr Chris Arridge is a physicist at Mullard Space Science Laboratory, UCL. He was one of the team of scientists that studied some of the first data sent back from Saturn by the Cassini spacecraft.

What does he research?

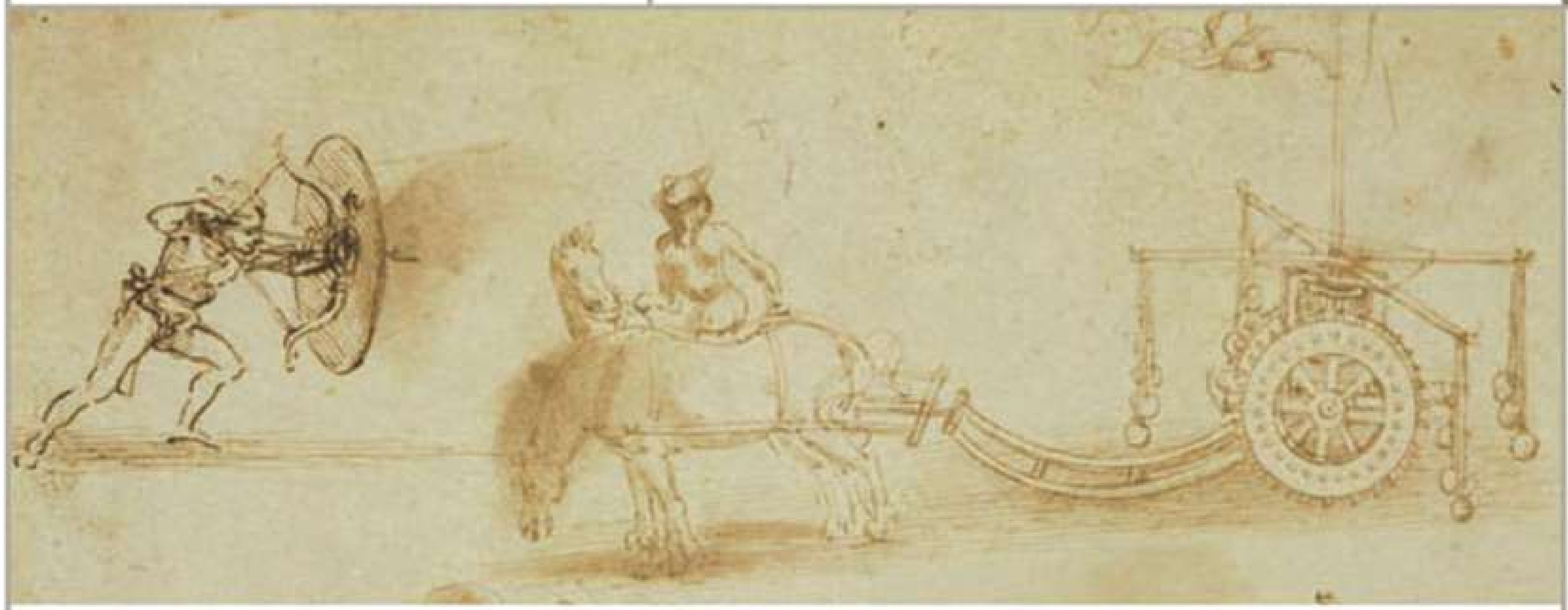
Big planets, or more precisely, the area surrounding the larger planets in our Solar System. Charged particles around Saturn and Jupiter are affected by the Sun, creating aurorae much like Earth's Northern Lights. Dr Arridge is investigating how the Sun's 11-year cycle affects these planets' magnetospheres.

What's he talking about?

This lecture, 'Strangers And Giants', is a tour of the outer reaches of our Solar System, looking at Jupiter, Saturn, Uranus and Neptune. Dr Arridge will explain some of the conundrums facing planetary scientists and will preview the upcoming space missions that will be heading to the outer planets.

Royal Astronomical Society, London, 1pm-2pm, free, www.ras.org.uk

Find out what future missions will teach us about the gas giants with Chris Arridge



Renaissance warfare: Leonardo's sketch of a flailing club chariot

15 JUNE

Ten Drawings By Leonardo da Vinci

Showcasing the polymath's incredible versatility, this touring exhibition of drawings from Windsor Castle includes anatomical sketches, designs for chariots with flailing clubs and a scheme to drain marshland.

Ulster Museum, Belfast, until 27 August, free, for full tour locations visit: www.royalcollection.org.uk/exhibitions

16 JUNE

Festival Of Nature

At Bristol's harbourside, discover the latest tech used by the BBC Natural History Unit, explore the pop-up wildlife garden and learn more about urban conservation. There are talks by presenters and experts, such as ecologist Huw Warwick and the Urban Birder, David Lindo – and keep an eye out for Pete the Bug Man and his exotic animals.

Bristol harbourside, free, www.bnhc.org.uk

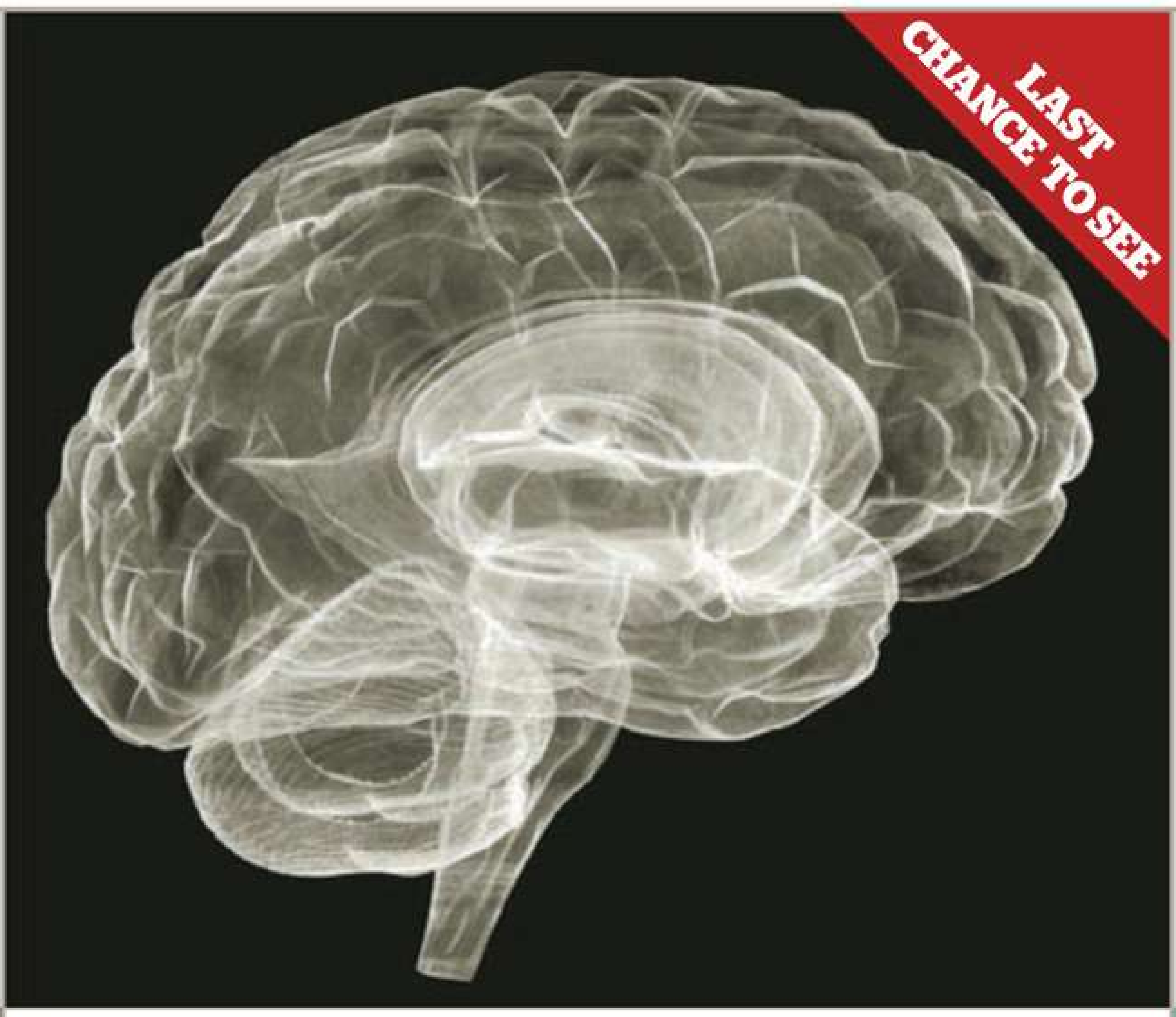
THINKSTOCK, MAX ALEXANDER, PAUL DODDS, WELLCOME TRUST, SCIENCE MUSEUM, CLAUS LANGER, THE ROYAL COLLECTION

17 JUNE

Robots Live!

Meet and talk with the scientists creating robots that could shape our future. Or, if you're feeling a little less cerebral, just enjoy the sight of robots trying to tear each other new exhaust vents, as the stars of *Robot Wars* take to the battlefield outside the museum.

National Museum Of Flight, East Lothian, 17 June, 10am-5pm, www.nms.ac.uk/whats_on/national_museum_of_flight.aspx


LAST CHANCE TO SEE

17 JUNE

Brains: The Mind As Matter

With 100 billion neurones and 100 trillion synapses, the brain is a formidably complex organ. In this exhibition, with real brains, artefacts and manuscripts on display, explore our grey matter's physiology, emotions, and the ethical wranglings raised through the centuries by medical intervention, scientific enquiry and technological advances.

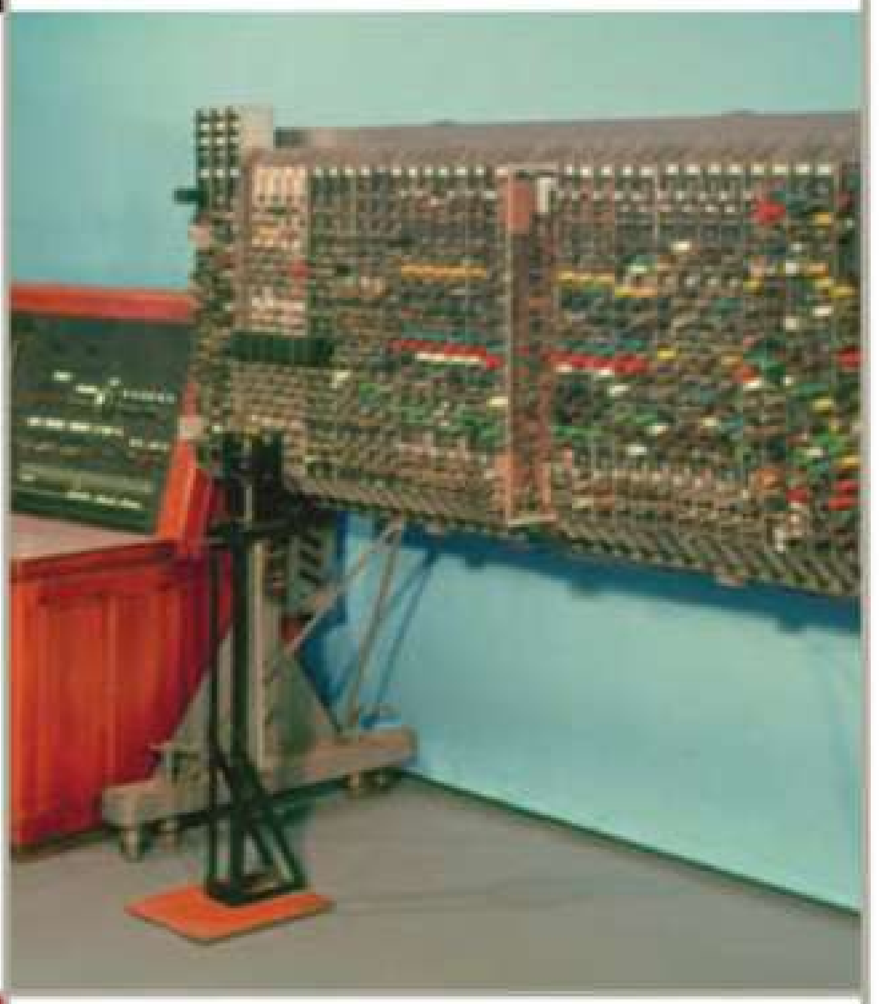
Wellcome Collection, London, 17 June, free, www.wellcomecollection.org

21 JUNE

Codebreaker: Alan Turing's Life And Legacy

The Turing machine was a key step in the evolution of the modern computer. On the centenary of Alan Turing's birth, discover more about the life and work of the pioneering mathematician, cryptanalyst and all-round über-brain through archives, photos and never-before-seen objects.

Science Museum, London, until May 2013, free, www.sciencemuseum.org.uk



22 JUNE

Hack The City

Over half of the world's seven billion people now live in cities. At this exhibition, discover how urbanites are adapting to hectic, cramped city life – from sustainable development to under-development, from greenfields to green politics, from social networking to flash mobs.

Science Gallery, Dublin, until 7 September, free, www.sciencegallery.com

20-23 JUNE

Supersonix

This three-day conference will take over London's Exhibition Road to bring together the latest research, art and theories on sound. The concert halls in the area will host performances and talks from musicians discussing the technical side of their art, while the museums will showcase the latest developments in sound technology and research. And if you don't want to get that technical, the street itself will be the venue for a day-long free music festival on 23 June.

Exhibition Road, London, day passes from £60/music festival free, see locations at www.exhibitionroad.com/supersonix

EDITOR'S CHOICE

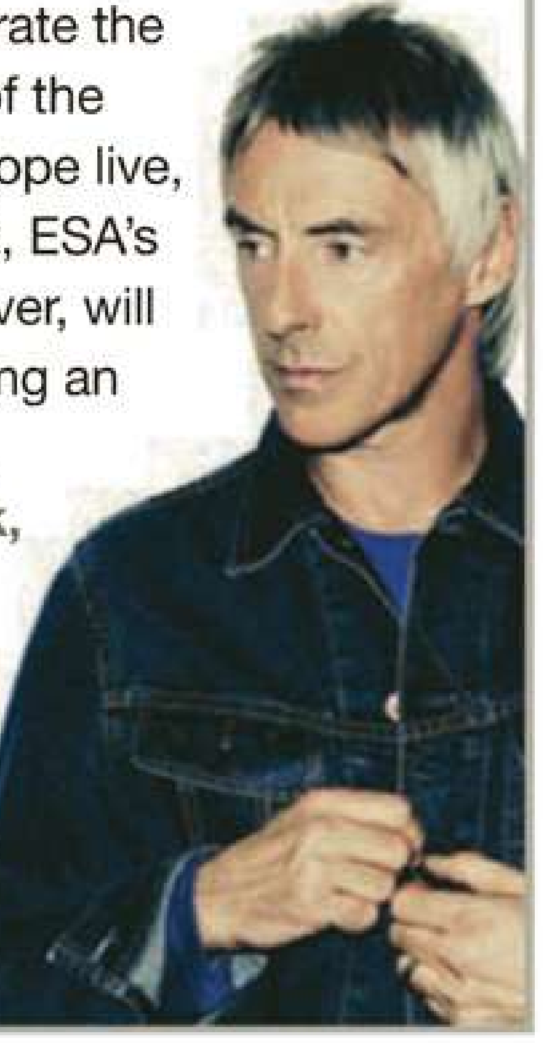
Danish artist Jacob Kirkegaard will be speaking on the opening day about his work with sound

23 JUNE

Live From Jodrell Bank

Paul Weller, Elbow, Graham Coxon and guests descend upon the world-famous observatory for an outdoor concert, paired with live science events throughout the day. Astrophysicist Tim O'Brien will demonstrate the capabilities of the Lovell Telescope live, while Bridget, ESA's next Mars rover, will also be making an appearance.

Jodrell Bank, Cheshire, £35, www.livefromjodrellbank.com



TV & RADIO

The month's top science programmes

Curiosity

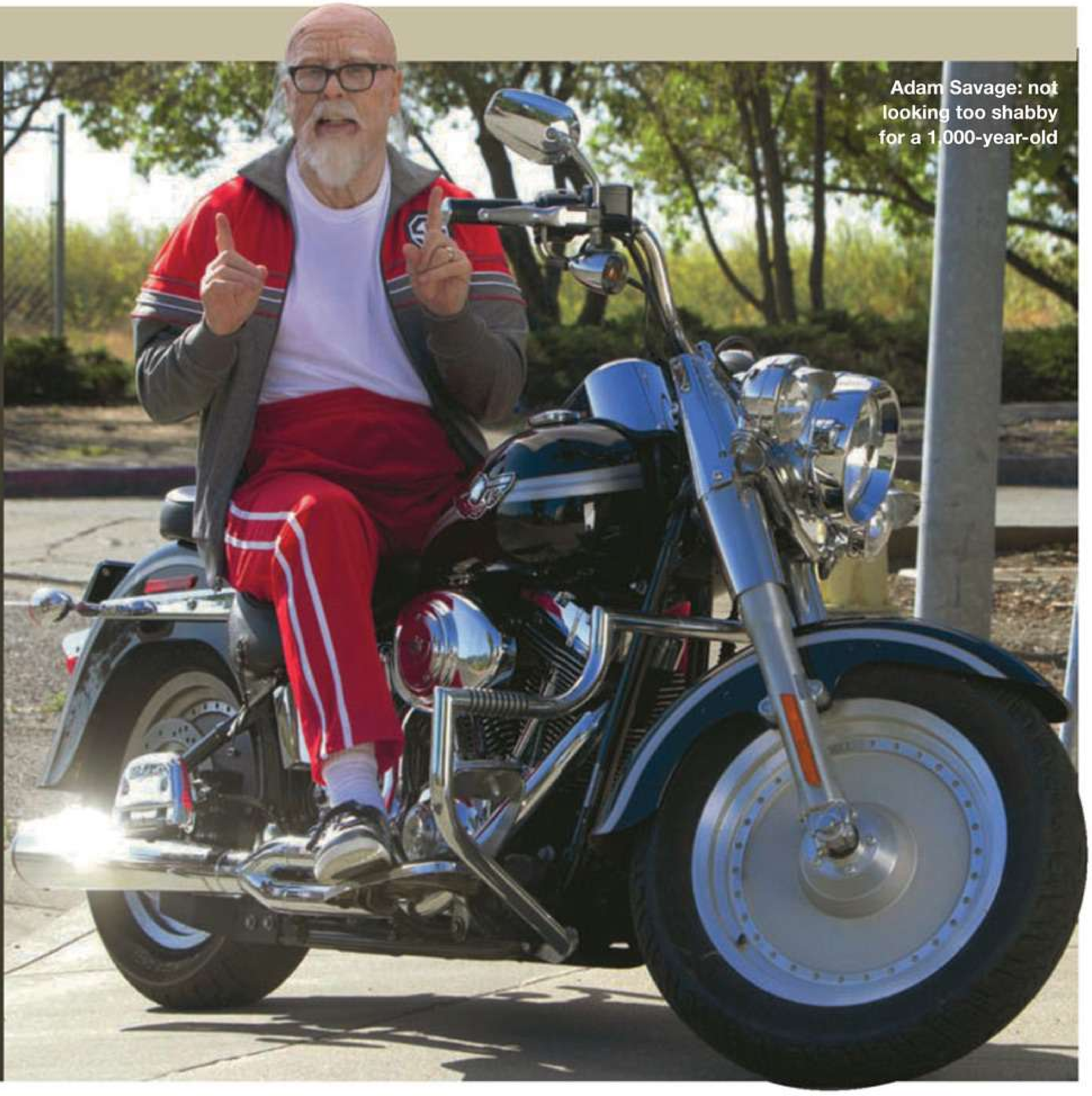
Discovery HD, Starts 10 June, 8pm

As you're reading *Focus*, then you're no doubt the sort of person who asks questions like "How does life begin?", "What would it be like to live forever?" and "What's on television in June?"

The last one we can help you with right now. For the first two, and more like them, try this new series. Celebrity presenters including Courtney Cox and Adam Savage get an episode each to pursue one of the big questions, using the tools of science to find answers.

In the first programme, 'Can you live forever?', 1,000-year-old host Adam Savage looks back from 2967AD to tell his story: how advances in medical science allowed him to live beyond the 21st century into the age of the cyberhuman. At this ripe old age he now needs spectacles, but he's managed to retain his trademark goatee. Could we be looking at the next stage of human evolution?

In later episodes, Courtney Cox zooms in on the beginning of human life, the brief period between conception and birth, and Bill Paxton asks what sank the Titanic. There's plenty of food for thought here.



Adam Savage: not looking too shabby for a 1,000-year-old

The House The 50s Built

Channel 4
June TBC

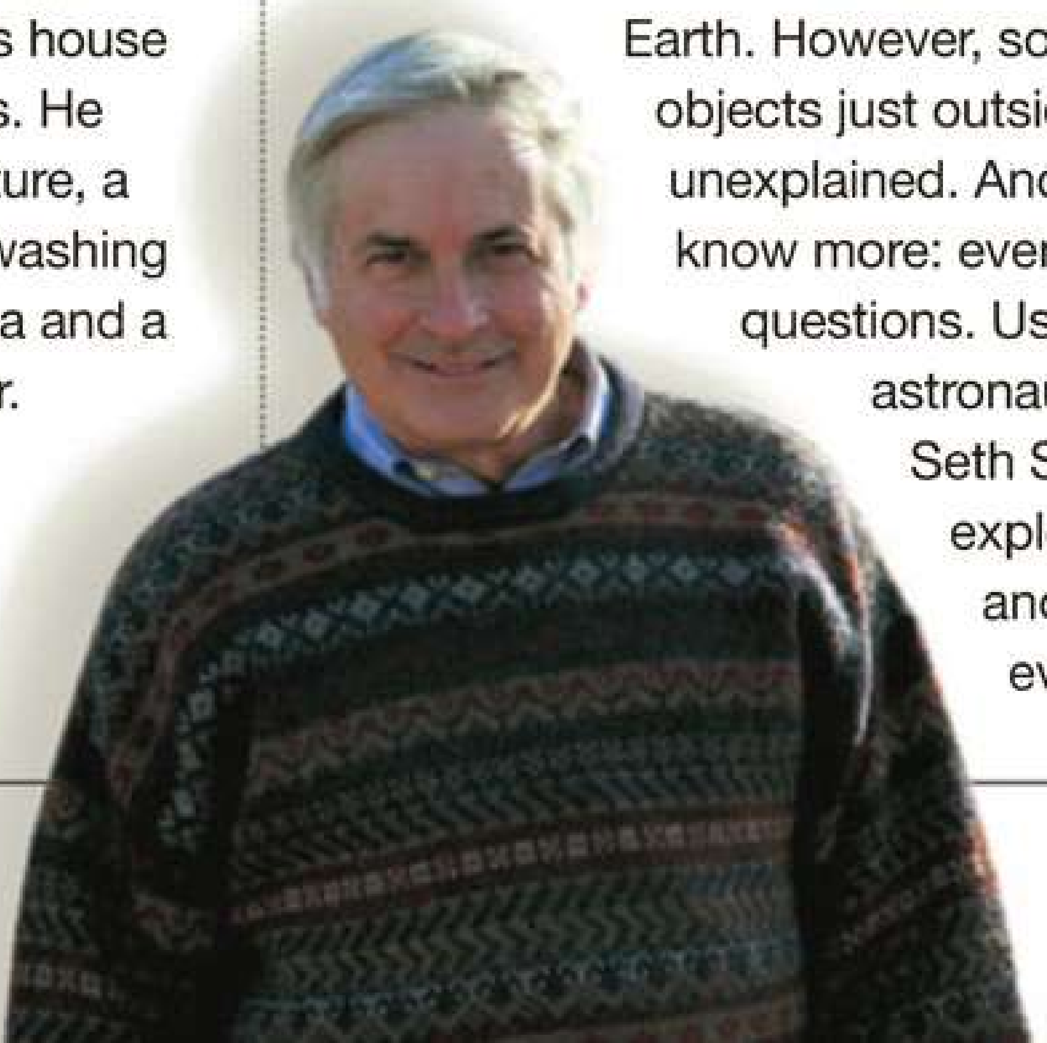
Celebrate the Diamond Jubilee Bank Holiday with a look back at the 1950s – the turning point between wartime Britain and the Space Age. In this four-part series, Prof Brendan Walker recreates a 1950s house and the engineering that transformed our lives. He starts in the kitchen, where freestanding furniture, a mangle and a larder quickly gave way to the washing machine and refrigerator. Brendan shows us how to make Formica and a non-stick pan, and turns a vat of chemicals into ladies' underwear.

As well as exploring the inventions of the era, we'll hear from people who remember the decade first hand, including writers Maureen Lipman and Fay Weldon, and from interior designers who relish its retro style.

NASA's Unexplained Files

Discovery HD
3 June, 8pm

Since its foundation in 1958, America's National Aeronautics and Space Administration has amassed a remarkable collection of images, among them the most iconic views of the Moon, astronauts and planet Earth. However, some of the images appear to show objects just outside Earth's atmosphere, which remain unexplained. And it's not just UFO spotters who want to know more: even NASA's astronauts have unanswered questions. Using NASA footage and interviews with astronauts and scientists, including astronomer Seth Shostak (pictured), this one-off special explores the top 10 unexplained sightings, and asks the question: could these be evidence of intelligent extraterrestrial life?



DISCOVERY NETWORKS X5, STORYHOUSE, STEVE SCHRENZEL, BBC, CHANNEL 4

Radio

The Infinite Monkey Cage

Radio 4

Starts 18 June, 4.30pm

Comedian Robin Ince and Professor Brian Cox return with a new season of this hugely popular series. Whether it's recorded in a studio or live at events including the Cheltenham Science Festival, you can expect guests from the worlds of science and comedy, some big questions and some serious (and silly) answers. Does not contain monkeys. Or cages. Or infinity. Given it's a radio programme of finite length, we're not even sure that would be possible.

Ben Moor: Undone

Radio4Extra

Starts 18 June, 6.30pm

The second series of this surreal sci-fi saga with Alex Tregear features comedy performers including Tim Key and Emma Kennedy. So don't expect too much hard physics as we enter parallel worlds in which London is not quite the city you might know. The wettest drought on record? Anti-aircraft missiles sited on blocks of flats? Sounds pretty surreal to us! Err, what do you mean that's the real London?

Does Science Need Spin?

Radio 4

Starts 26 June, 11am

Whether you call it science communication, public engagement, or simply the new rock plus roll, there has seldom been more science in mainstream and popular culture. Researchers are encouraged, trained and even paid to go and talk about their work, reaching out to the public to build a new atmosphere of trust and mutual respect. But is it actually working? In this series, Geoff Watts digs into some uncomfortable trends and asks what can be done to heal the rift.

Meteorite Men

Discovery Science
Starts 1 June, 10pm

A second series following modern-day treasure hunters Steve Arnold and Geoff Notkin. Instead of gold, they're hunting down fragments from outer space, some of which exploded into our planet's atmosphere centuries ago, and have lain buried deep in the ground ever since. Eight episodes take us on a mission to retrieve relics of the early Solar System, some of them more than 40 million years old.

Prophets Of Science Fiction

Quest
Starts 3 June, 9pm

Ridley Scott, director of *Alien* and *Blade Runner*, explores the links between sci-fi and real-world technology in this eight-part series. Each episode focuses on one auteur: from Jules Verne to George Lucas via Isaac Asimov, whose Three Laws of Robotics are applied in AI research. We're looking forward to seeing how Philip K Dick's visions shaped the future.

Crimes That Changed History

Nat Geo
Starts 4 June, 9pm

Forensic science is a relatively young discipline, and this series pinpoints the crimes that brought about revolutions in detection. For example, DNA profiling was first used in the 1980s to solve a series of murders in one English town, while the use of fingerprints as a unique identifying pattern dates back to late 19th century Argentina. The squeamish should probably avoid the episode on entomology…

American Weed

Nat Geo
Starts 13 June, 9pm

The Netherlands may be trying to tighten up on marijuana use, but in the USA one state has a much more relaxed attitude. Since 2004, medical use of cannabis has been legal in Colorado. This series unveils the new cannabis culture that's been thriving in Denver and across the state. Patients, entrepreneurs and cops talk about how toleration has changed their lives. It seems that in Boulder, you can get legally stoned.

World's Toughest Drive

Discovery HD
21/28 June, 9pm

Some journeys cannot be done in a people carrier – they demand a rugged 4x4. And a 700-mile drive from the Antarctic coast to the South Pole is one of them. Just in case crevasses deeper than your car and metal-shattering temperatures 89 degrees below zero aren't enough of a challenge, the team are taking along an amateur who's never even camped in snow. Hope he's remembered his driving gloves…

Incredible Human Journey

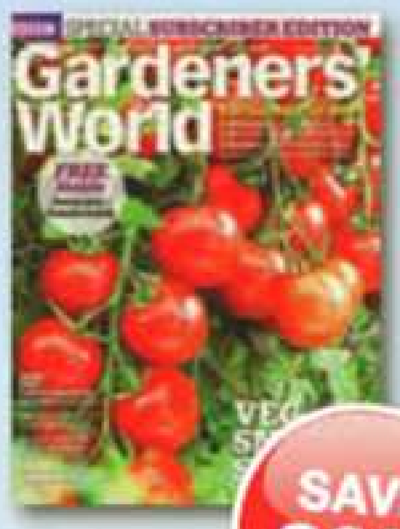
Eden
Starts 25 June, 9pm

This is another chance to see Dr Alice Roberts travel the globe in the footprints of our ancestors. By putting together clues from modern human life, DNA evidence and palaeontology, she tells the story of our species. Starting in Africa, a small and vulnerable group of early humans began a series of migrations that laid the foundations of today's diverse civilisations. It'll make your Bank Holiday drive with the family look like nothing!

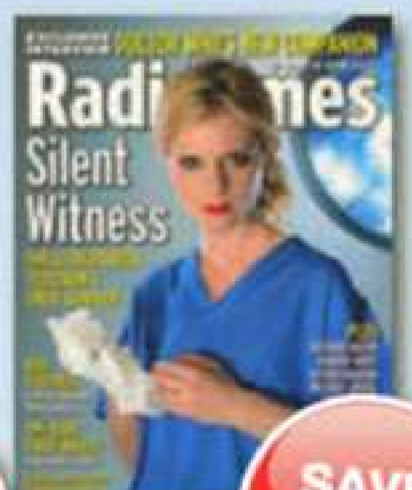
Looking for an original Father's Day gift?

With every gift subscription we will send you a free gift card for you to personalise

SAVE UP TO 40% with this unique and thoughtful magazine subscription gift this Father's Day… from gardening to fast cars, science to music, inspiration for your next holiday or the essential guide to TV and radio, there's a magazine to suit every man's taste. Order today to guarantee that you purchase the perfect gift this Father's Day.


SAVE 30%
12 Issues £31.92

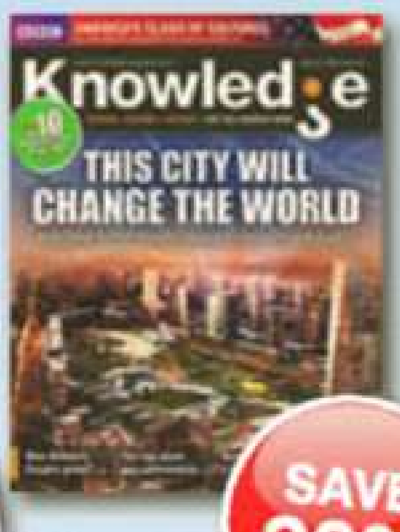
SAVE 30%
12 issues £31.50


SAVE 10%
26 Issues £36.25*

SAVE 30%
13 issues £35.50

SAVE 40%
13 issues £38.90

SAVE 30%
12 issues £30.00


SAVE 20%
6 issues £19.00

SAVE 35%
13 Issues £36.00

SAVE 25%
12 issues £32.00

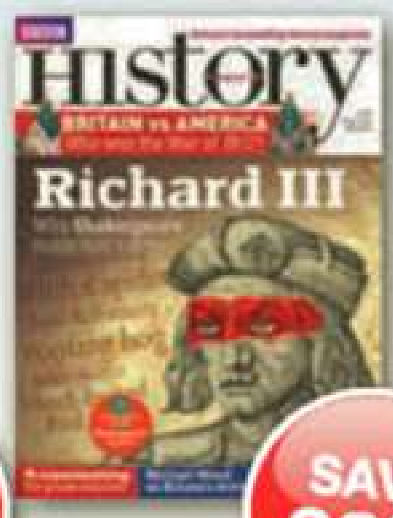
SAVE 30%
12 issues £39.90

SAVE 35%
13 issues £40.50

SAVE 30%
13 issues £34.50

SAVE 32%
13 issues £34.50

SAVE 36%
13 issues £32.50


SAVE 32%
13 issues £34.50

SAVE 40%
13 issues £30.81

3 easy ways to subscribe

Call
0844 844 0260
Quote Code FDFOP12

Visit
www.buysubscriptions.com/fathersday
Quote Code FDFOP12

Post
Quote Code FDFOP12
Complete the order form and send it to the address on the coupon below

Go online for a further discount by Direct Debit (excluding Koi).

Please complete the order form and send it to: Immediate Media Company, FREEPOST RSTB-HAAA-EHHG, Sittingbourne, Kent ME9 8PX. Campaign Code: FDFOP12

Your details (essential)

Your choice of magazine(s)** ______ Price ______
Title ______ Forename ______ Surname ______
Address ______
Postcode ______ Email address † ______
Daytime Tel Number ______ Mobile Number † ______

Gift recipient details

Your choice of magazine(s)** ______ Price ______
Title ______ Forename ______ Surname ______
Email address ______
Address ______
Postcode ______ Daytime Tel Number ______

This offer is available for UK delivery addresses only. Father's Day gift subscriptions will start with the next available issue after Sunday 17 June 2012. Should the magazine ordered change in frequency; we will honour the number of issues and not the term of the subscription. Overseas rates are available on request. Prices are discounted from the full UK subscription price and include P&P apart from Radio Times. Calling the 0844 844 0260 order number from a BT landline will cost no more than 5p per minute. Calls from mobiles and other providers may vary. Lines open Monday – Friday 8am-8pm and Saturday 9am-1pm. For enquiries, lines are open Monday – Friday 9am-6pm. **Offer ends Sunday 17th June 2012.**

*Radio Times subscriptions are for 26 weekly issues (6 months). The Basic Annual Rate for UK subscriptions is £80.60. This price is for 51 issues, which includes the Christmas double issue and a contribution towards first class postage.

Payment Details

☐ I enclose a cheque made payable to Immediate Media Co Ltd, or ☐ please debit the following amount from my credit/debit card: £ ______ Mastercard ☐ Visa ☐ Maestro ☐

Card Number
☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Valid from ☐☐/☐☐ Expiry date ☐☐/☐☐ Issue No. (Maestro) ☐☐

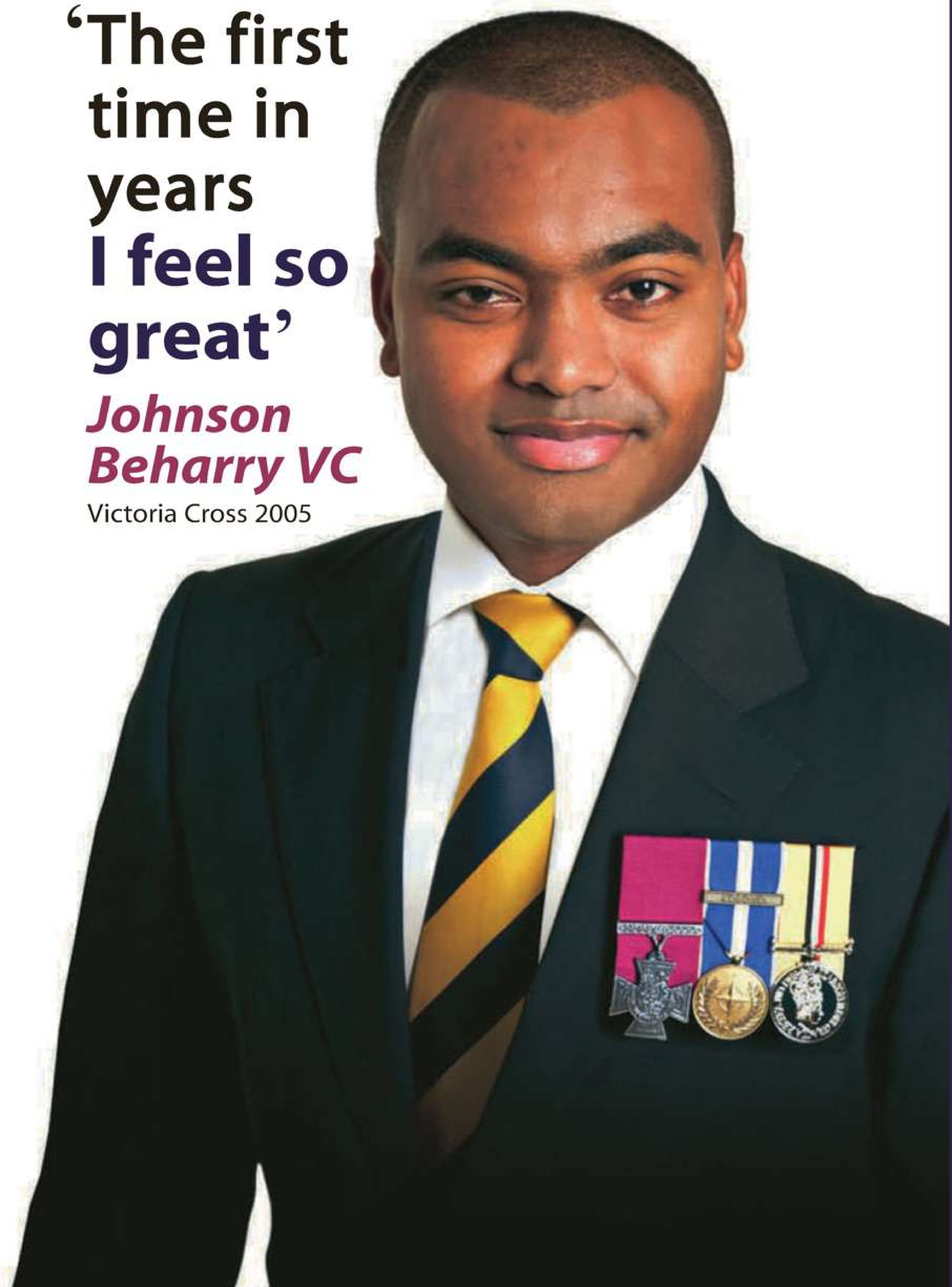
Signature ______ Date ______

** For Radio Times subscriptions please indicate which region you require. London, Anglia & Midlands ☐ South, West & South West ☐ North West, Yorkshire & North East ☐ Scotland & Border ☐ Wales ☐ Northern Ireland ☐. Please note, if a region is not selected subscribers will automatically receive the London, Anglia & Midlands region.

† Immediate Media Company Limited would love to keep you informed by post or telephone of special offers and promotions from the Immediate Media Company Group. Please tick if you'd prefer not to receive these ☐.

☐ Please tick here if you'd like to receive newsletters, special offers and other promotions by email or text message from the Immediate Media Company Group. You may unsubscribe from these at any time.

Please note that Top Gear, Good Food and Lonely Planet magazines are published in partnership with BBC Worldwide. If you would like to be contacted by them, please tick here. ☐



‘The first time in years I feel so great’

Johnson Beharry VC

Victoria Cross 2005

*‘I would like to express my gratitude to Vitabiotics for their supplements. **Neurozan®** has helped to maintain my brain function, and **Wellman®** has really helped to maintain my overall health, vitality and performance. I even managed to compete in the highly strenuous **Dancing on Ice** due to the help from Vitabiotics.’*

JBeharry VC

Johnson Beharry VC

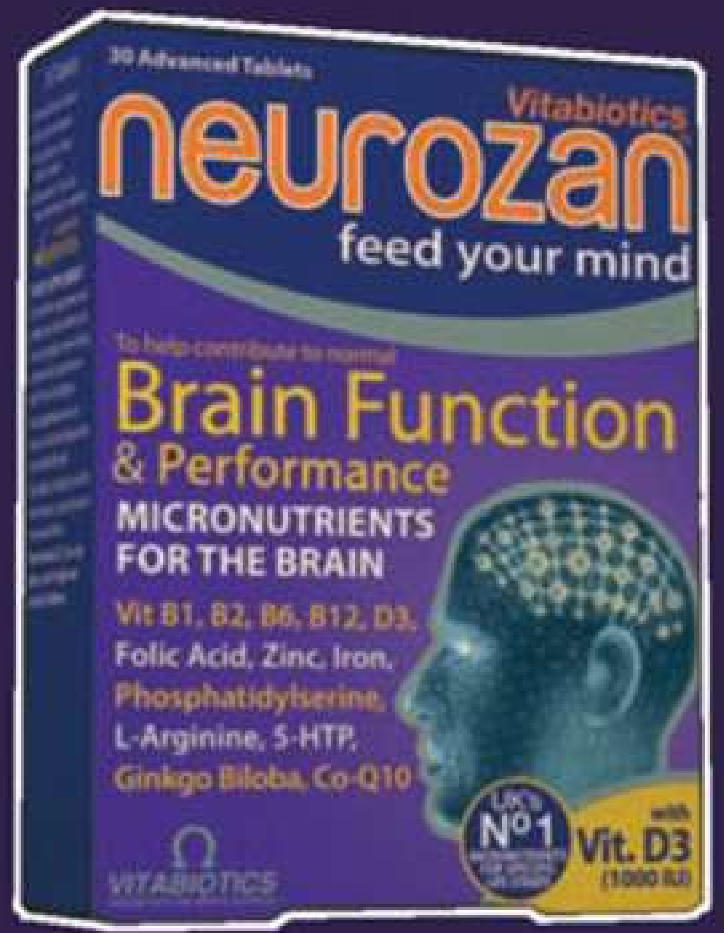
◆

In Tribute to Great Heroism

Johnson Beharry is one of a distinguished few to receive the Victoria Cross, Britain’s highest award for gallantry and the ultimate symbol of sacrifice and courage. Johnson Beharry carried out two individual acts of great heroism by which he saved the lives of his comrades... at great personal risk to himself (one leading to him sustaining very serious injuries). Beharry displayed repeated extreme gallantry and unquestioned valour.

VITABIOTICS
WHERE NATURE MEETS SCIENCE

Vitabiotics supports
TICKETS FOR TROOPS



Neurozan® tablets
Neurozan® is an advanced micronutrient formula with specific nutrients to help contribute to normal brain and neurological function.

Wellman® tablets
Wellman® is an expertly formulated, award-winning micronutrient supplement, tailored to help support specific male nutritional requirements.

Available from

Boots

40 YEARS

Britain’s leading supplements for specific life stages

From Boots, Superdrug, supermarkets, Holland & Barrett, Lloydspharmacy, chemists, GNC, health stores & www.vitabiotics.com

Vitamin supplements may benefit those with nutritionally inadequate diets.

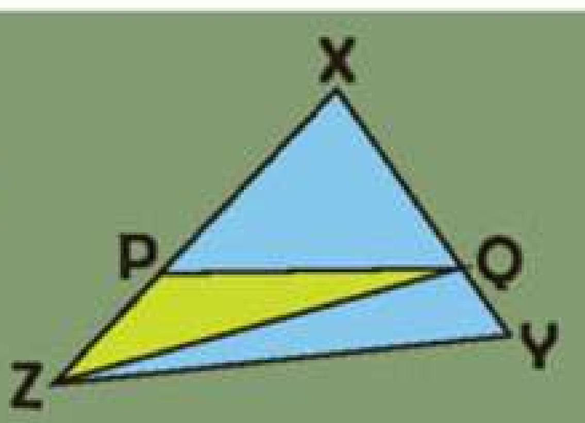
BRAINTRAINING

Pit your wits against these brainteasers by **David J Bodycombe**, question-setter for BBC Four's *Only Connect*

Win
How To Teach Relativity To Your Dog, worth £11.99

Prize Puzzle

***P** is two-thirds of the way down the **XZ** line, and **Q** is three-quarters of the way down the **XY** line. If **XYZ** has an area of 20 units, what is the area of **PQZ**?*



The first five correct entries drawn will win a copy of *How To Teach Relativity To Your Dog* by Chad Orzel (Basic, £11.99). Post your entry, marked 'Prize Puzzle 243', to: Focus Magazine, PO Box 501, Leicester, LE94 0AA by 5pm on 28 June 2012. We regret that we cannot accept email entries for this competition.

See bottom of p80 for terms and conditions. Congratulations to Alan Smith (Middlesex), Elaine Lewis (Herts) and E McCurtcheon (Cheshire) who all answered April's Prize Puzzle correctly to win a Maglite torch.

See ***sciencefocus.com/winners*** for previous winners and solutions

QUESTION 1

'King Phillip Came Over From Great Spain' is a way of remembering which hierarchy?

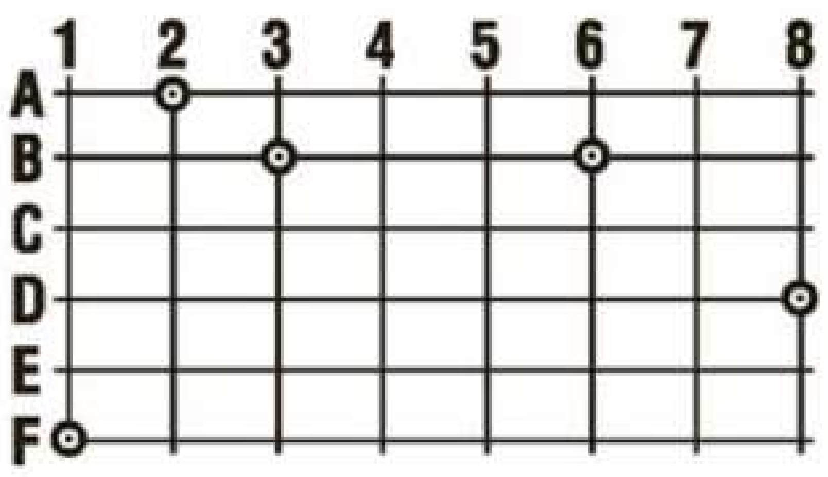
QUESTION 2

Make every row, column and both diagonals total 42:

	5	
		6

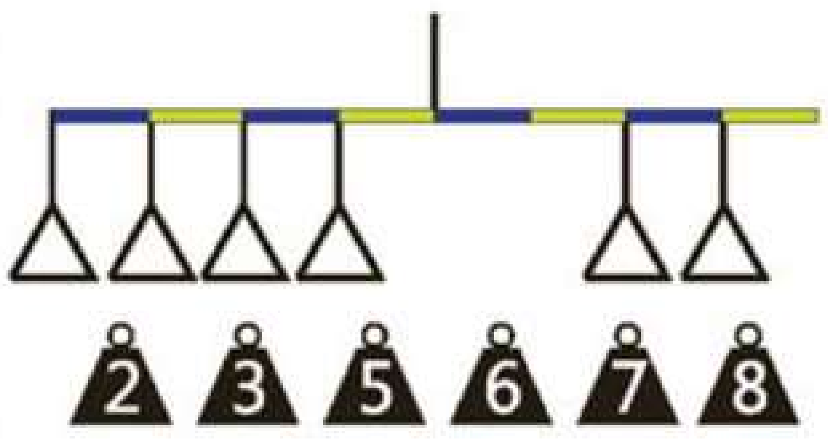
QUESTION 3

Five friends are currently at the road intersections marked on this plan. Where is the fairest place for them to meet up?



QUESTION 4

Place all the weights on the pans so that the rod is perfectly balanced. (Assume weight of rods/pans = 0)

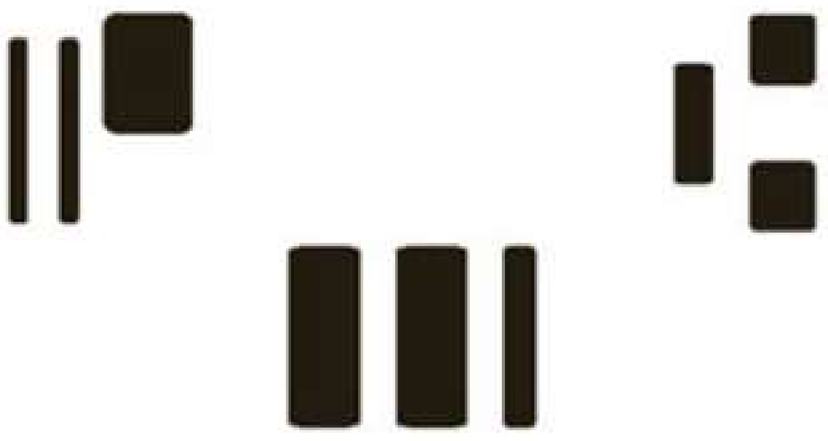


QUESTION 5

Using seven 8s and the four basic arithmetic operations, how can you arrive at the result 1,000?

QUESTION 6

Most adults will have seen these three distinctive symbols many times before – where?

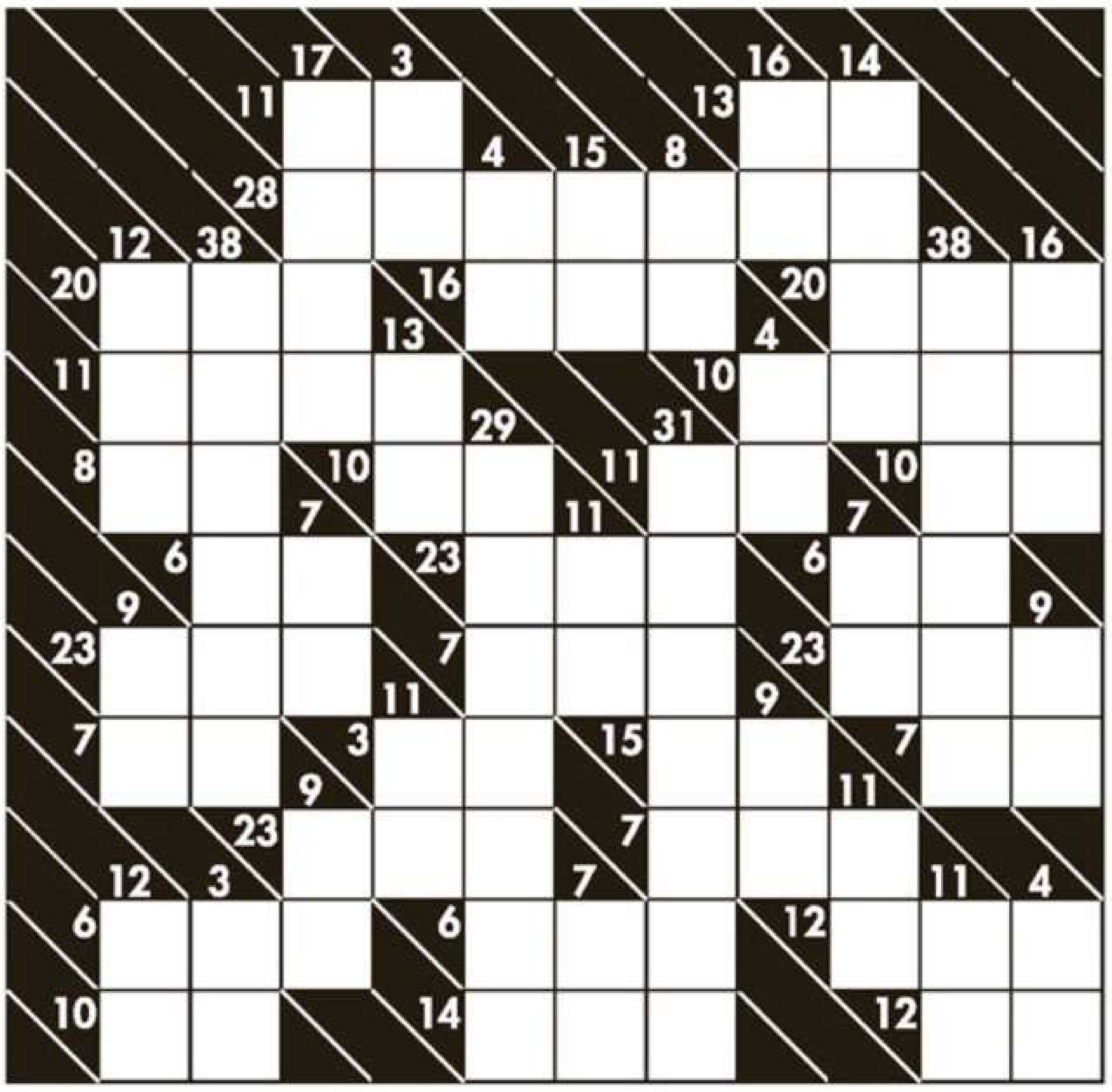


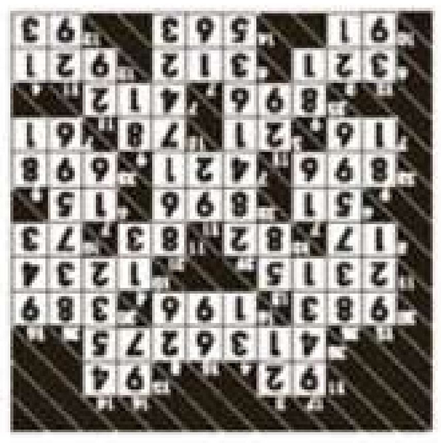
QUESTION 7

0.027027027… is 1 divided by which number?

QUESTION 8

In this crossword called a Kakuro, fill in the blank squares using digits from 1 to 9 inclusive. The given clues show the total of the digits for each 'answer', across and down. Also, every answer never contains a repeated digit – eg if three boxes total 6, they must contain 1, 2 and 3 in some order.





Solutions

Q1) Biological classifications in decreasing size: Kingdom, Phylum, Class, Order, Family, Genus, Species.
Q2) Row by row: (22, 5, 15) (7, 14, 21) (13, 23, 6). Q3) At point C4. Average out the horizontal coordinates: (1 + 2 + 3 + 6 + 8) /5 = 4, and similarly with the vertical ones.
Q4) One of seven solutions (from left to right): 2, 3, 5, 7, 8, 6. (The calculation uses weight x distance for each weight: 2x4 + 3x3 + 5x2 + 7x1 = 34 = 8x2 + 6x3.)
Q5) ((8 + 8) x 8 x 8) – 8 – 8 – 8. Q6) They can be seen on the bottom of a cheque, amongst the cheque and bank account numbers.
Q7) If x = 0.027027027…, then 1000x = 27.027027… = 27+x. Hence, 999x = 27, so x = 27/999 = 1/37. Q8) See illustration.

Quick Quiz

Test your knowledge of the Moon

QUESTION 1
Roughly how many billions of years ago did the Moon form?
a) 1.5
b) 4.5
c) 7.5

QUESTION 2
Which Apollo mission was the first to use a lunar rover?
a) Apollo 11
b) Apollo 13
c) Apollo 15

QUESTION 3
What name refers to the dark, basaltic plains on the lunar surface?
a) Maria
b) Julia
c) Sophia

QUESTION 4
Which Ancient Greek geographer first associated the Earth's tides with the Moon?
a) Hipparchus
b) Eratosthenes
c) Pytheas

QUESTION 5
In what year did Luna 2 become the first unmanned spacecraft to reach the Moon?
a) 1951
b) 1955
c) 1959

QUESTION 6
On average, how many full Moons are there in one calendar year?
a) 6
b) 12
c) 18

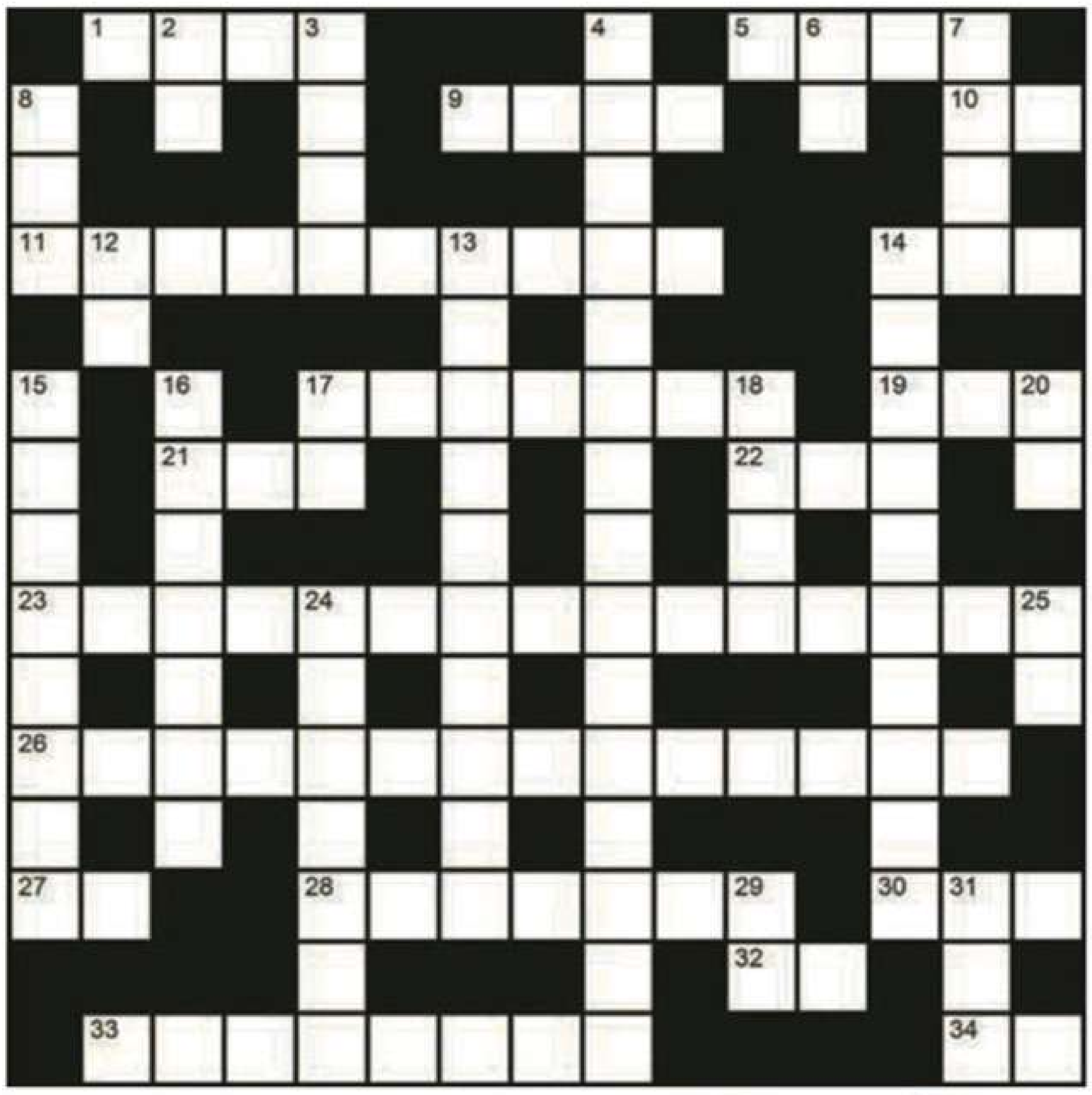
QUESTION 7
When will the next total lunar eclipse take place?
a) April 2014
b) April 2024
c) April 2034

YOU ARE:
0-3 A lunatic
4-5 Neil Armstrong
6-7 The Man in the Moon

Answers: 1b, 2c, 3a, 4c, 5c, 6b, 7a

EVERY MONTH, A NEW CHALLENGE SET BY **ARCHIMEDES**

Science **crossword** Nº 2



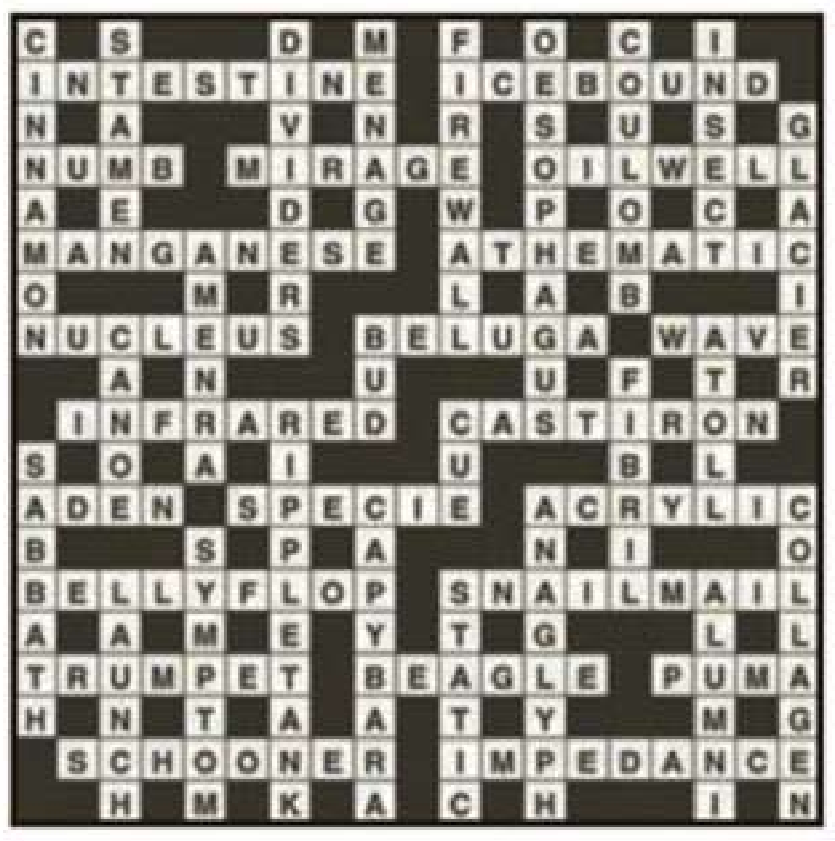
Across

1 The foetus develops inside this organ (4)
5 In electronics, a single voltage provided by the power supply unit is called a voltage ____ (4)
9 Dark, combustible rock composed mainly of carbon (4)
10 The angular distance of a celestial object, measured around the observer's horizon (abbreviation) (2)
11 Renewable alternative to fossil fuels; drives turbines (4,6)
14 Medical X-ray scan used to look inside the body (abbreviation) (3)
17 Fuming red-brown liquid; one of the halogen elements (7)
19 Digital logic gate that only generates a 1 if both inputs are 0 (3)
21 Organ of sight (3)
22 Alternative name for the alimentary canal (3)
23 Movement of molecules across a cell membrane to a higher concentration (6,9)
26 American seismologist who gave his name to an earthquake scale (7,7)
27 Female sex chromosomes (2)
28 Notoriously poisonous metalloid (7)
30 The Big ___ was a radio telescope that detected the "Wow!" signal (3)
32 Electromagnetic radiation that causes sunburn (abbreviation) (2)
33 Type of spiralled fossil (8)
34 Mathematical constant; ratio of a circle's circumference to its diameter (2

Down

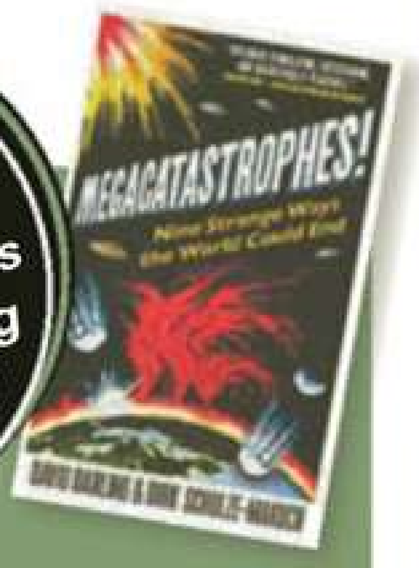
2 One of the two states described by binary code (2)
3 Substance capable of reacting with acid to form a salt and water (4)
4 In physics, symmetric property of a field theory, first seen in classical electromagnetism (5,10)
6 Metal with the highest electrical conductivity (chemical symbol) (2)
7 Molten rock erupted from a volcano (4)
8 In optics, Snell's ___ is used to calculate the angle of refraction (3)
12 According to Freud, the aspect of the psyche associated with basic drives (2)
13 Process by which a cell discharges large particles (10)
14 On a chromosome, the closest point between two sister chromatids (10)
15 TV physicist from Lancashire (5,3)
16 In anatomy, relating to the front or underside of an animal (7)
17 Chemical symbol of beryllium (2)
18 ____ are produced inside ovaries (4)
20 Rare platinum group metal discovered in 1844 (chemical symbol) (2)
24 Vesuvius is one of these (7)
25 Transition metal commonly used in capacitors (chemical symbol) (2)
29 Wires are often made from this metal (chemical symbol) (2)
31 SI unit of electric current (3)

Solution to No 139



Congratulations to AP Coniam (Kent), Susan Wilton (Northumberland) and Julie Anne James (Bridgend) who correctly solved April's puzzle (No 139) and receive a copy of *The Better Angels Of Our Nature* by Stephen Pinker.

Win
Megacatastrophes by David Darling worth £10.99


MEGACATASTROPHES!
Nine Strange Ways the World Could End
DAVID DARLING & DIRK SCHULZE-MAKUCH

The first three correct solutions drawn will each win a copy of Megacatastrophes by David Darling. Entries must be received by 5pm on 28 June 2012, after which the winners will be randomly drawn.

YOUR DETAILS

NAME:

ADDRESS:

POSTCODE: **TEL:**

EMAIL:

Post entries to BBC *Focus Magazine*, July 2012 Crossword, PO Box 501, Leicester, LE94 0AA or email a scan of the completed crossword or a list of answers to july2012@focuscomps.co.uk by 5pm on 28 June 2012. Entrants must supply name, address and phone number. By entering, participants agree to be bound by the terms & conditions, printed in full on page 80. Immediate Media, publisher of *Focus*, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' on your email or postal entry if you do not want to receive such information by post or phone. Please write your email address on your postal entry if you would like to receive such information by email.

Supported by

uy tickets:

t-bristol.org.uk/ourworld

SITA trust

Get Fit For Summer

Essential gear to help you shed the pounds for the holiday season

Compex

Muscle stimulation with the help of Compex helps you to exercise more muscle fibres, more precisely and in less time. Compex enables athletes to individualise and optimise their workouts, so peak performance can be achieved.

Muscle stimulation is not meant to be a replacement for traditional strength training exercises, it's a complement to your existing sports training programme — allowing you to target your training for increased power, endurance, speed and strength. **www.compex.info**

Train anywhere in the world with iFit Live

Transport yourself to a different workout location every day using the new pioneering iFit Live technology. The first ever product to merge fitness equipment with Google Maps technology, it enables you to run, cycle or train anywhere in the world. From New York's Central Park to Sydney Harbour, download personalised workouts straight to your treadmill, bike or elliptical and you'll have the world at your feet!

For more information on the full range of all iFit Live compatible products please visit:
www.ifit.com or call **0845 177 0514**

ProForm

ProForm Introduces the Official Tour de France Training Bike. The first indoor bike with motorised Real Road Resistance technology, combines cycling's most prestigious event with the latest innovations. The Tour de France training bike, inclines and declines as it progresses along a programmed route to simulate the mapped terrain. It does this by utilising iFit Live technology which is powered by Google Maps, so users can see and experience a course, right from the comfort of their own home.

For more information on the full ProForm Fitness product range please visit:
www.proformfitness.co.uk
or call **0845 177 0512**

A Startling Memory Feat That *You* Can Do

"How I learned the secret in one evening. It has helped me every day."

When my old friend Richard Faulkner invited me to a dinner party at his house, I little thought it would be the direct means of doubling my salary in less than two years. Yet it was, and here is the way it all came about.

Towards the end of the evening things began to drag a bit as they often do at parties. Finally someone suggested the old idea of having everyone do a 'party-piece'.

Finally it came to Peter Brown's turn. He said he had a simple 'trick' which he hoped we would like. First he asked to be blindfolded. Those present were to call out 25 random numbers of three figures each and he asked me to list the numbers in order as they were called.

Peter then astounded everyone by repeating the entire list of 25 numbers backwards and forwards. Then he asked people to request numbers by their position in the list. Instantly he repeated back the correct number in the positions called. He did this with the entire list without making a single mistake.

"There was really nothing to it – simply a memory feat"

On the way home that evening I asked Peter Brown how it was done. He said there was really nothing to it — simply a memory feat. Anyone could develop a good memory, he said, by following a few simple rules. And then he told me exactly how to do it.

What Peter said I took to heart. In one evening I made remarkable strides towards improving my memory. In just a few days I learned to do exactly what he had done.

The most gratifying thing about the improvement of my memory was the remarkable way it helped me in business and in my social life. I discovered that my memory training had literally put a razor edge on my mind. My thinking had become clearer, quicker, keener. I was fast acquiring that mental grasp and alertness I had so often admired in men who were spoken of as "brilliant" and "geniuses".

"I can instantly recall anything I want to remember"

Then I noticed a marked improvement in my writing and conversational powers. What's more my salary has increased dramatically.

These are only a few of the hundreds of ways I have profited by my trained memory. No longer do I suffer the frustration of meeting people I know and not being able to recall their names. The moment I see someone I have met before a name leaps into my mind. Now I find it easy to recall everything I read. I can now master a subject in considerably less time than before. Price lists, reports, quotations, data of all kinds. I can recall in detail almost at will.

What Peter told me that eventful evening was this: "Send for details of Dr. Bruno Furst's Memory Course." I did. That was my first step in learning to do all the remarkable things I have told you about. In fact, I was so impressed that I got permission to publish Dr. Furst's Course myself.

"Dramatic Improvement"

"I used to be laughed at in the office here about my poor memory and I must admit with a lot of truth. Since I started your Course my memory has improved out of all recognition!"

Mr. J.W. Sullivan, London S.W.2.

My advice to you now is don't wait another minute. Full details of Dr. Furst's remarkable Course are available free on request. You could be amazed how a powerful memory can improve your life - send for full details **TODAY!**

BOB HEAP

FREE INFORMATION PACK AND BOOKLET AVAILABLE

For your copy visit our website at

www.youcanremember.com

or call us with your details FREE on

0800 298 7070 quoting Focus Magazine

Please send me your **FREE** Memory information pack and booklet.

Name ....

Address..

....Postcode..............................

Memory and Concentration Studies

Freepost FOM22T, Stockport, Cheshire SK6 6YA.

Email: FOM22E@youcanremember.com

Please include your full name and postal address

TRANSFER old Slides, Negatives & Photos DIRECT to SD Memory Card

FREE 1GB SD CARD enough to store 1000 images!

No PC needed!

Fastest and easiest way to transfer Photos, Slides and 35mm Negatives all to Digital.

Large 2.4" Full Colour LCD Preview Screen!

Scanned images can be previewed, edited and saved to digital, quickly & without a computer.

Bring your much-loved photos, film negative and slide collection to life by transforming them into digital files and save directly to SD card – NO PC REQUIRED!

Scanned images can be previewed, edited and saved to digital, quickly and without a computer. Once saved to SD card you can playback images on a digital photo frame, television using the video output connection (lead supplied), your mobile phone, computer, or take them to be printed!

neostar electronics

SAVE £40

RRP ~~£129.95~~

Just £89.95

FREE DELIVERY

"A superb piece of kit. Easy to use. Very quick process" M JANES, Theydon Bois.

MORE CUSTOMER REVIEWS AVAILABLE ONLINE.

FEATURES INCLUDE

- ✔ 5 Mega pixel CMOS sensor takes two seconds to scan and save colour / black and white slides / negatives / photographs (will also scan up to 10 mega pixel quality– interpolated).
- ✔ Preview images on its built-in colour 2.4" LCD screen and edit images using 'mirror' and 'rotate' buttons for correcting backwards / upside down / portrait images. All without a computer!
- ✔ Automatically adjusts focus, exposure, and colour balance so you don't have to be a computer whiz to achieve fabulous results.
- ✔ An optional-use USB port and cable supplied for connecting to a PC / laptop (drag files from SD card to computer).
- ✔ Mains or USB powered, comes with 1 negative and 1 slide holder plus three photo trays (3"x5", 4"x6" and 5"x7"), a handy cleaning brush and a FREE 1GB SD memory card (enough to store 1000 images).

STEP 1

Insert slides, negatives or photographs into scanner

STEP 2

Preview, edit and save scanned images to SD card

STEP 3

Playback images on digital photo frame, TV, computer, etc.

STEP 4

Attach the USB lead to PC for safe long term storage and printing

SCAN MORE, SAVE MORE! Extra slide/negative holders are available for £9.95 for three and an extra 4GB SD card costs £12.95 and 8GB SD card £19.95.

3 EASY WAYS TO ORDER

WATCH THE VIDEO ONLINE

Call 01794 527 450

Please quote code QF2054 when ordering

Visit www.MySmartBuy.com

Post coupon to: MySmartBuy.com Ltd, (QF2054), PO BOX 299, Romsey SO51 0WH.

PayPal

mysmartbuy.com

formerly t2 tECHNOLOGY in tHE HOME Inspired Ideas, Brilliant Value

Free 7-day delivery to UK mainland. Please call for special delivery services: Express, A.M., Saturday and non-UK mainland. Customers have 30-days from receipt of goods to approve purchase. If needed simply call us to arrange return of item (undamaged and in original packaging) for a replacement/ refund. Call us in the UK directly for FREE on many network calling plans (no expensive 0870 number). Charges may vary. MySmartBuy.com Ltd, previously T2 Direct. (Reg. No. 4926647) Emery House, Units 7-9 Romsey Ind. Est., Greatbridge Road, Romsey, SO51 0WH.

100% GUARANTEE! No risk 30-day approval period

ORDER FORM

Please send me:

ITEM	PRICE	QTY	TOTAL
MU631 Photo, Film & Slide to SD Scanner (RRP £129.95) **SAVE £40**	£89.95		
FSSLD1 3 x Extra Slide Holders	£9.95		
FSNEG 3 x Extra Negative Holders	£9.95		
DD4SD 4GB SD Memory Card	£12.95		
DD8SD 8GB SD Memory Card	£19.95		
DEP48 Optional 48-hour Delivery	£4.95		
FREE 7 DAY DELIVERY	**FREE**		
	GRAND TOTAL		

I enclose Cheque/ P.O. made payable to **MySmartBuy.com Ltd** for £ ____________
(Please write your name and address on back of cheque) or charge my MasterCard/Visa/Maestro/Visa Electron.

My card number is ____________

Security Code (last 3 digits on back of card) ____________

Start Date ______ / ______ Expiry Date ______ / ______

Issue No. (Maestro cards) ____________

Name Mr/Mrs/Miss/Ms ____________

To: MySmartBuy.com
Ltd, (QF2054),
PO BOX 299,
Romsey SO51 0WH.

THANK YOU for your order

Signature ____________

Address ____________

Post Code ____________

Telephone ____________

Email (For despatch update) ____________

Free delivery - allow up to 7 days for delivery. If you do not wish to receive mailings from other companies, please tick box ☐

uclan
University of Central Lancashire

STUDY AT HOME WITH STUDYASTRONOMY.COM

Study from home with some of the world's leading experts

As one of the world's leading providers of distance learning courses in astronomy, UCLan offers a variety of opportunities to study.

Our University Certificates are designed for people with little or no prior knowledge.

University Certificates:

- Astronomy
- Astrobiology
- Sun, Earth and Climate
- Cosmology

Following completion of these courses, students can go on to further study leading to more advanced awards:

Certificate of Higher Education in Astronomy

Diploma of Higher Education in Astronomy

BSc (Hons) Astronomy

For further information visit:
www.studyastronomy.com

Thursday 19 – Friday 27 July
Wrexham Science Festival

Kick-start the summer holidays with a bang!

experiments, workshops, energy, fun, interactive events and much more for adults and kids alike.

Highlights include:

- BBC wildlife presenter **Kate Humble** in conversation
- Special **Olympics** themed events
- The Science of **Doctor Who** and **Superheroes**, and the **Chemistry of Cocktails**
- **Lego robot** workshops
- Comedians **Helen Keen** and **Matt Parker** with their unique shows blending comedy and science

And much much more!

Open your eyes to the world of science at Glyndŵr University, Wrexham – just 45 minutes from Liverpool and Manchester

Full programme released in June!

www.wrexhamsf.com
wsf@glyndwr.ac.uk
01978 293466

Sign up to our mailing list

Find us on:
facebook.com/wrexhamsciencefestival
twitter.com/wrexhamscifest

How To Become A Successful Writer!

As a freelance writer, you can earn very good money in your spare time, writing the stories, articles, books, scripts etc that editors and publishers want. Millions of pounds are paid annually in fees and royalties. Earning your share can be fun, profitable and creatively most fulfilling.

To help you become a successful writer we offer you a first-class, home-study course from professional writers – with individual guidance from expert tutors and flexible tuition tailored to your own requirements. You are shown how to make the most of your abilities, where to find ideas, how to turn them into publishable writing and how to sell them. In short, we show you exactly how to become a published writer. **If you want writing success – this is the way to start!**

Whatever your writing ambitions, we can help you to achieve them. For we give you an effective, stimulating and most enjoyable creative writing course… appreciated by students and acclaimed by experts.

It's ideal for beginners. No previous experience or special background is required. You write and study at your own pace – you do not have to rush – as you have four years to complete your course. **Many others have been successful this way.** If they can do it – why can't you?

We are so confident that we can help you become a published writer that we give you a **full refund guarantee.** If you have not earned your course fees from published writing by the time you finish the course, we will refund them in full.

If you want to be a writer start by requesting a free copy of our prospectus 'Write and be Published'. Please call our freephone number or visit our website NOW.

COURSE FEATURES

- 30 FACT-PACKED MODULES
- 3 SPECIALIST HANDBOOKS
- 20 WRITTEN ASSIGNMENTS
- ADVISORY SERVICE
- TUTORIAL SUPPORT
- FLEXIBLE STUDY PROGRAMME
- STUDENT COMMUNITY AREA
- HOW TO PRESENT YOUR WORK
- HOW TO SELL YOUR WRITING
- 15 DAY TRIAL PERIOD
- FULL REFUND GUARANTEE

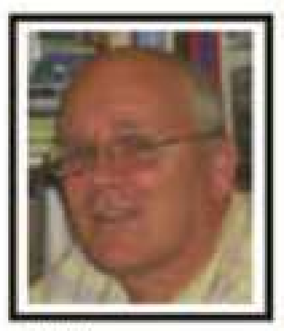
www.writersbureau.com

☎ **FREEPHONE**
24 HOURS
0800 856 2008

Save £30 Quote JL

email: 12W1@writersbureau.com
Please include your name and address

AWARD WINNING WRITER
Christina Jones, Oxfordshire
"So far, I have had eighteen novels published! The Writers Bureau helped make this possible for me. Within six months of enrolling on my course I was having work commissioned by editors and I still work regularly for magazines."



Michael Foley, Essex
"Completing The Writers Bureau course has made it possible for me to attain my life-long ambition of becoming a published writer. The level of success I have achieved has far outweighed what I was hoping for when beginning the course. By the end of this year I should have eight books already published and hopefully two more finished."

Cindy-Lou Dale, Kent
"I thought you'd like to know that seven years since doing my course at WB I've been published in more than 150 magazines around the world. I've now got to the stage where I'm turning down all-inclusive exotic press trips!"

Please send me free details on how to become a successful, freelance writer:

NAME ……………………………………………
ADDRESS ……………………………………………
……………………………………………
…………………………………… POST CODE ……………
EMAIL ……………………………………………

Freepost RSSK-JZAC-JCJG
The Writers Bureau
Dept JL12315
Manchester, M3 1LE

23 Years of Success

Members of The British Institute for Learning and Development and ABCC

CELESTRON

SKYPRODIGY

WINNER OF THE PRESTIGIOUS 2011 CES INNOVATIONS AWARD FOR DESIGN AND ENGINEERING EXCELLENCE

StarSense TECHNOLOGY

SkyProdigy. THE SMARTEST TELESCOPE IN THE UNIVERSE!

No knowledge of the night sky is required. One touch innovation turns anyone into an instant astronomer!

It is that SMART.

To discover more and to find your nearest Celestron dealer please visit **www.celestron.uk.com**

Celestron is distributed in the UK, Ireland and Scandinavia by:

Dealer enquiries welcomed.

DavidHinds Ltd

Celestron®, SkyProdigy™ and StarSense™ are trademark or a registered trademark of Celestron Acquisition, LLC in the United States and in dozens of other countries around the world. All rights reserved. David Hinds Ltd is an authorised distributor and reseller of Celestron products. All telephone calls are recorded for training and quality control purposes.

David Hinds Ltd Unit R, Cherrycourt Way
Leighton Buzzard, Bedfordshire LU7 4UH

RAT stands

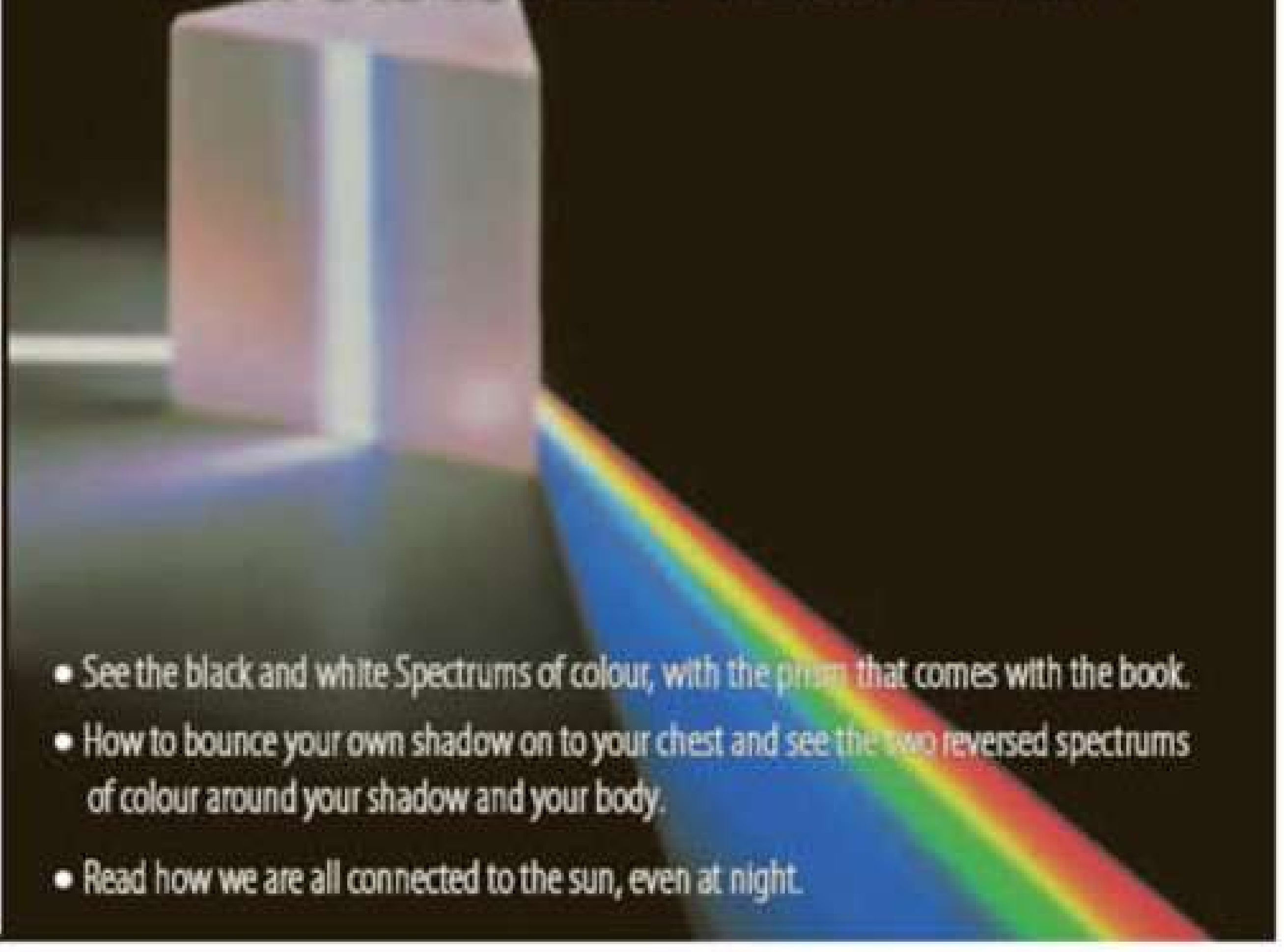
Z3 - the iPad floor stand
versatile, lightweight, convenient.... and folds flat in just 3 moves.

TEL: +44 (0)20 8741 4804 WEB: www.ratstands.com

Send £14.99
(p&p included)
or overseas £24.99 to

J V Moloney
8 Mayflower Way,
Slough SL2 3TX

NEW DISCOVERY-BLACK LIGHT



- See the black and white Spectrums of colour, with the prism that comes with the book.
- How to bounce your own shadow on to your chest and see the two reversed spectrums of colour around your shadow and your body.
- Read how we are all connected to the sun, even at night.

Astronomy by Distance Learning

The Liverpool Telescope in La Palma
A Liverpool Telescope image of M16
liverpool JMU

- Exploring The Universe
- Astronomy for Teaching
- The Science of Science Fiction
- Planetary Geology
- The Universe Through a Small Telescope
- Galaxies
- Stars
- The Universe Through a Large Telescope
- Planetary Atmospheres
- Modern Cosmology
- Gamma Ray Bursts
- Exoplanets

Background image: A Liverpool Telescope image of Cassini 2001??

For More Details:
0151 231 2900
enquiry@astro.ljmu.ac.uk
www.astro.ljmu.ac.uk/distance

All Courses accredited by LJMU

AUTHORS

Synopses and sample chapters welcome, please send to:

AUSTIN & MACAULEY PUBLISHERS LTD

Austin & Macauley Publishers
CGC-33-01, 25 Canada Square,
Canary Wharf, London, E14 5LQ
0207 0388212
editors@austinmacauley.com
www.austinmacauley.com

All genres welcome

MAGIC BY POST

100's of amazing tricks YOU can do!
Exclusive offers at
www.MagicbyPost.co.uk

HayFever? HayMax®

Sick of this...
then try this...

HayMax
HAYFEVER? Sneezing? STOP the Pollen
Organic Drug-Free Pollen Barrier Balm
Pure
Lavender
Aloe Vera

Award-Winning
Drug-Free Pollen Barrier Balm
Natural, Organic; No Drowsy Side Effects
- Simple to Use and Proven to Trap Pollen
- Suitable for children and pregnant women
- Now proven to trap allergens from dust and pets

3 for price of 2
at participating independent health stores & pharmacies, www.haymax.biz & 01525 406 600

Recommended
in The Times, The Independent, Daily Mail, by Dr Chris Steele MBE on ITV1, and many, many more

Available from ASDA HOLLAND & BARRETT + selected TESCO Waitrose Boots

Then, Now & Next

SYNTHETIC LIFE

A hundred years of trying to create life from scratch is starting to come to fruition

WORDS: PENNY SARCHET
ILLUSTRATION: DANNY ALLISON

THEN

In 1912, the German-American biologist Jacques Loeb published *The Mechanistic Conception Of Life*. Bringing together 20 years of scientific research and metaphysical musings, it saw him proclaimed by some as “undoubtedly one of the greatest experimental geniuses”. In his most famous experiment, Loeb showed that a sea urchin egg could be induced to begin embryonic development without the need for a sperm cell. Exposing these eggs to a specific concentration of salt water prompted them to start dividing – a form of artificial parthenogenesis.

Loeb argued that the ‘riddle of life’ could be explained by chemistry and physics. He believed that by controlling life, we could build a more rational society with ethical and biological principles rooted in fact. However, it was his proposal to create life artificially that attracted the most attention. “We must either succeed in producing living matter artificially or we must find the reasons why this is impossible,” Loeb said.

NOW

Today, scientists continue to tinker with the creation of life, working with organisms far more complex than sea urchins. By removing the genetic material from a sheep egg cell and replacing it with adult sheep DNA, the world’s first animal, named Dolly, was cloned in 1996. A stream of other cloned animals has followed, the latest addition being a pashmina goat born in India this March.

Much like Loeb’s sea urchins, cloning techniques bypass the need for fertilisation, but require pre-existing cells and genetic material. In 2010, biologist Craig Venter and his team moved one step closer to artificial life. They synthesised a genome from computer DNA data and placed it inside a bacterial cell, the DNA of which had been removed. The replacement genome was able to run the living cell, keeping it alive and allowing it to reproduce.

This ability to ‘print’ a genome was seen by some as the first hurdle to making a fully synthetic cell.

NEXT

Hybrid cells, pieced together from bits of DNA from across nature, are just around the corner. The possible benefits to society are wide ranging. Bacteria and yeast cells, modified with genes from other organisms to produce useful chemicals, could find uses across industry, engineering and medicine. Brewers’ yeast, reprogrammed to produce diesel instead of alcohol, might help meet the world’s fuel demands. Engineered bacteria, trapped inside nanotube cages and implanted in the body, could be used to release therapeutic drugs to anyone from cancer patients to UV-sick astronauts. Furthermore, Russian and South Korean scientists recently announced their intentions to clone a woolly mammoth using elephant eggs and ancient mammoth DNA.

One day, teams like Venter’s may be able to build artificial cells from scratch. However, whether such an achievement would provoke a dramatic shift in our philosophical beliefs, as originally predicted by Loeb, remains to be seen.

ILLUSTRATION BY DANNY ALLISON

THE FUTURE SOUND OF LONDON

The PAL+ is old-fashioned cool for the digital age. It's small, portable and – in its new Limited Edition Union Jack design – a rather beautiful DAB radio. It will get flawless reception where many other radios won't and has a rechargeable NiMH battery, providing 10 hours play.

The PAL+ is weather-resistant, making it perfect for British summers. It's ready to go straight out of the box, and its 3.5mm aux input makes the PAL+ the perfect partner for any smartphone or MP3 player.

And, just in case that street party keeps you up late, it also features an auto set clock and dual alarms with snooze functionality.

www.tivoliaudio.co.uk

For free p&p please quote BBCfocus in the discount code box

Tivoli Audio™
The Original Radio Company.

Your reception results may vary. All prices, features, specifications and availability are subject to change without notice. Tivoli Audio, the Tivoli Audio logo, PAL, and Portable Audio Laboratory are trademarks of Tivoli Audio, LLC. Other product and company names mentioned herein may be trademarks of their respective companies.

SAMSUNG

Phone? Tablet? It's much more.

It's Galaxy Note!

Samsung GALAXY Note

5.3" HD SUPER AMOLED

Precise S Pen Input

www.samsung.com/uk/galaxynote

Screen images simulated. ©2012 Samsung Electronics Co. Ltd.